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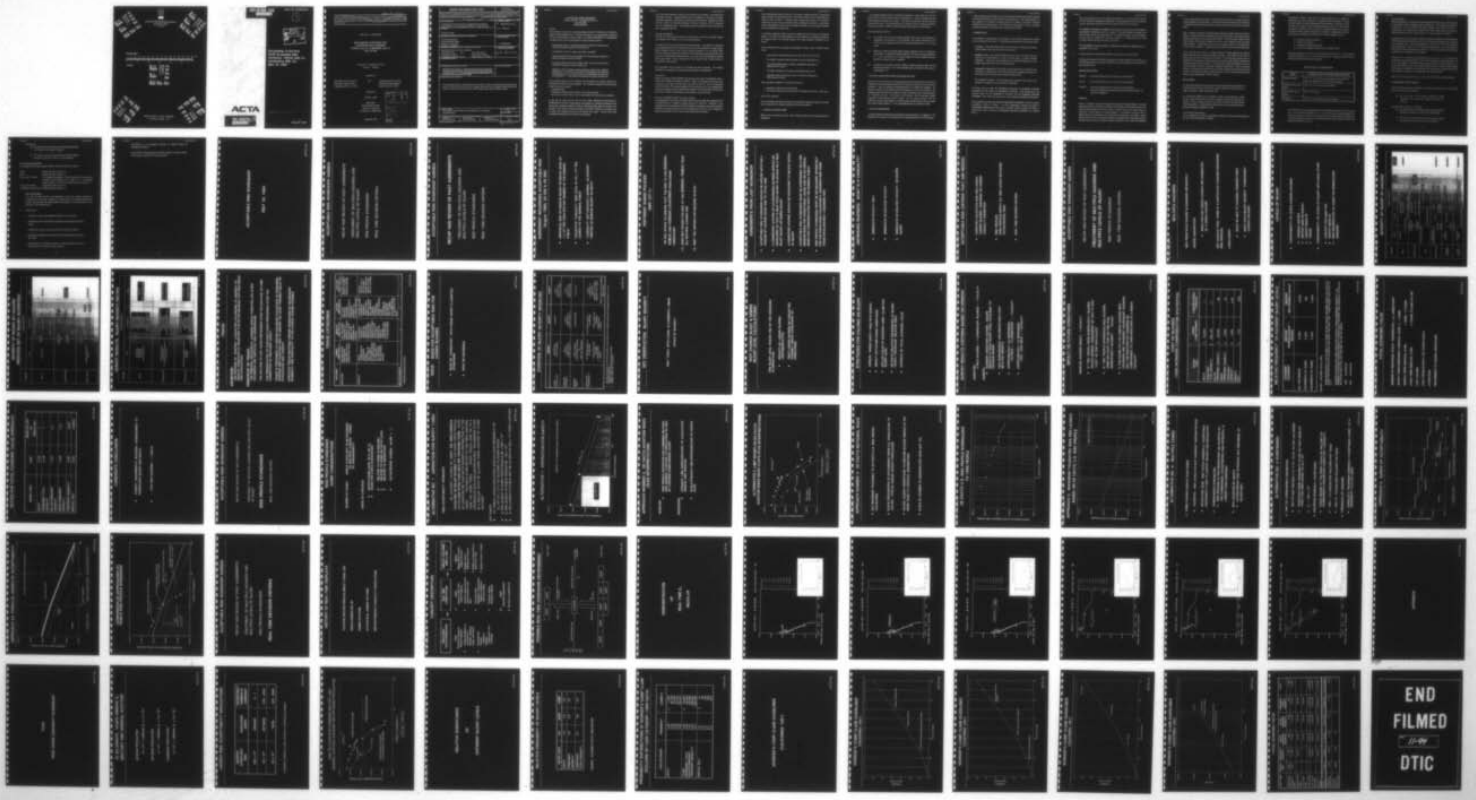

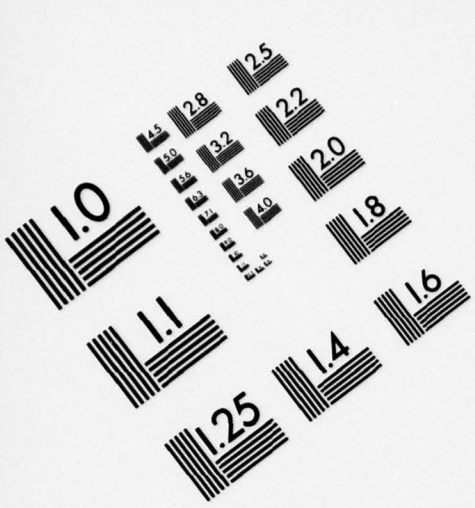

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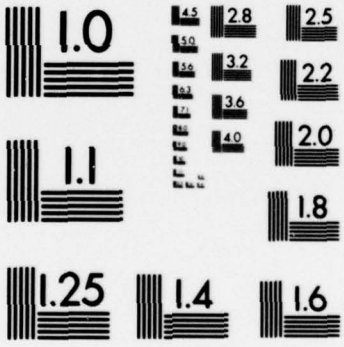

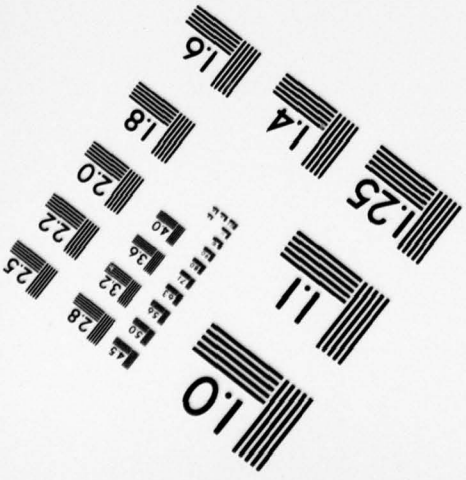

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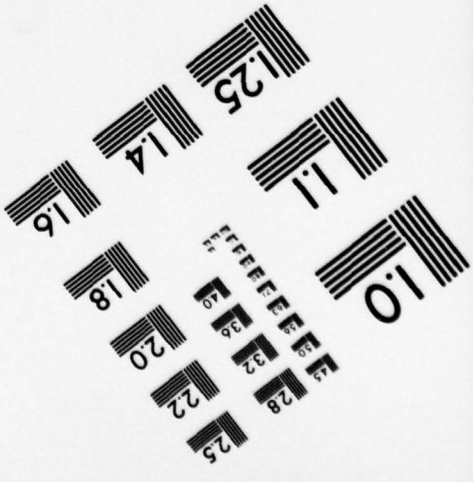

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13. ABSTRACT *(Maximum 200 words)*

This report documents a workshop conducted on May 18, 1994, including the Safety Directorates of the 30 SW and the 45 SW and their support contractors for the purpose of determining the manner in which risk profiles will be used to support range safety decision making.

14. SUBJECT TERMS

Risk Profiles, Debris Hazards, Blast Hazards, Toxic Hazards, Acceptable Risk

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ACCEPTABLE RISK WORKSHOP
Patrick AFB, FL / Vandenberg AFB, CA
May 18, 1994
PROCEEDINGS

1. *History:*

The workshop was part of a continuing dialog between 30 SW/SE and 45 SW/SE to address risk acceptability issues. Discussion between the two organizations in February and July 1989 initiated the current dialog. The RISK/COMMONALITY WORKSHOP of August 22-23, 1990 was motivated by several important reasons:

- Encroachment issues at Vandenberg (ranches southeast of the base) and at Cape Canaveral/KSC (public and press access);
- Consolidation of the two ranges under Space Command;
- Added recognition of the risks undertaken by Shuttle launches without an inadvertent separation destruct system;
- Increased public awareness of national safety issues and the need for evenhanded treatment on similar ranges; and
- Alignment with commonly accepted industry practice and standards regarding risk. (The Tenera study of 1990 recommended (1) more rigorous documentation process; (2) better definition of acceptable risk levels; and (3) expression of "... risks should be normalized for proper comparisons.)

This workshop marked a major milestone with the adoption of common standards for individual and collective risk acceptability. The workshop recognized several important issues that were not resolved:

- catastrophic risk
- treatment of different levels of injury in the decision process
- the need for a more effective way to communicate risk than casualty expectation

In the fall of 1992 and the fall of 1993 RISK PROFILE/ACCEPTABILITY WORKSHOPS were held. Risk profiles were adopted for expressing catastrophic risks. During these workshops suitable models for calculating range safety risk profiles were presented. The issue of a risk profile standard was explored. Questions of multiple levels of injury and combining risks from all hazards were raised. Several risk profile acceptability standards used in Europe were presented.

All of the criteria applied to a facility, not an activity (*e.g.*, a launch). All criteria show catastrophe aversion -- disproportionately lower probabilities of occurrence for higher numbers of casualties. Standards are expressed on an annual basis. Standards are of the form $f \bullet n^c$, where f is the annual frequency of at least n casualties, with $c>1$ (typically two, for n sufficiently large). The standards attempt to anchor the curves with some *de facto* acceptable risk level.

2. *Synopsis of Workshop:*

The May 18, 1994 workshop focussed on the issues of 1) treatment of multiple hazards and multiple levels of injury, and 2) risk profile standards.

Currently, the risk from each hazard is managed separately. This approach is supported by the assumption that for any single launch the risks are dominated by a single hazard. While frequently this has been a good working assumption, it is not always valid. Moreover, the issue becomes more important with risk profiles as different portions of the curve may be dominated by different hazards. As a result, it must be possible to combine risks across hazards. Such a combination of risks is possible only if injury severity is "comparable" across hazards.

Four approaches were presented for developing risk profile standards. The resulting standards were compared to demonstrate their similarities and differences.

3. *Participants:*

Messrs. Lou Ullian, Mike Campbell, Jerry Kaevats, Ron Angus, Dan Berlinrut, and Lt. Colonel Bob Thunker represented 45 SW/SE. Messrs. Leo Aragon, Martin Kinna, Ron Cortopassi, Cory Cather, and Mark Berte represented 30 SW/SE. FSC was represented by Mr. Ted Eckert. RTI was represented by Mr. Loyd Parker. ACTA was represented by Jerry Haber, Kingston George, James Baeker, Hal Reck, Jon Collins, Karl Overbeck, Jack Howe, Steve Carbon, James Hudson, Lloyd Philipson, and Kevin Benn.

4. *Treatment of Multiple Hazards and Levels of Injury:*

The participants at the previous workshop decided that acceptable risk standards should be applied both on a hazard by hazard basis and to total risk. Moreover, it was recognized that (1) occasionally it has been desirable to separately report debris fatalities and debris casualties and (2) the current modeling efforts for toxic risk are targeted to produce three distinct levels of injury: mild, significant and fatalities.

These developments raised the need (1) to develop a consistent means of categorizing injury severity across hazards and (2) to determine the relative level of undesirability of different levels of injury. Consistent injury categorization allows for meaningful comparisons of risks from each hazard and for combining risk estimates. Assessing the relative undesirability of each injury level makes it possible to have consistent standards of risk acceptability by injury level.

At an earlier workshop a matrix was used to categorize levels of injury for the different hazards. This matrix was updated based on survey responses by workshop participants. The updated matrix was presented together with triage guidelines (suggested by M. Kinna).

Several alternatives were presented for assessing the *relative value* of different injury levels:

- Range Safety Analysts Opinion Survey (ER, WR, RTI, and ACTA)
- The impact of various adverse outcomes on future range operations
- The relative dollar values of workers compensation payments for different levels of injury
- The relative frequency of occurrence of different injury levels
- Estimates of the total economic value of the losses resulting from different levels of injury.

These approaches suggested two possible conclusions:

1. Significant injuries are as bad as deaths.
2. One death is approximately three orders of magnitude worse than a mild injury.

5. *Risk Profile Standards:*

Several candidate risk profile standards were presented to stimulate thought and provide some initial basis for candidate acceptable risk profile standards:

a. **Aspiration for Safety (1990)**

Based on the conclusions from the 1990 workshop safety has the following objective (aspiration):

"...an accident causing *at least 10 simultaneous fatalities or major injuries to the work force* should occur *less often than once per thousand years.* Given 33 launches per year (both ranges) contributing to the "bank"... The public is restricted to ten times less risk than the work force... which would lead us to a criterion of 30 in a million per launch. Excursions to 300 in a million would be allowed when justified by other factors."

The key points from this are:

(1) An accident with at least 10 serious casualties to the work force should have a probability of no more than 3×10^{-5} per launch. The public is restricted to a risk of 10 or more casualties per launch of one-tenth that amount or 3×10^{-6} per launch.

(2) Based on (1) and the tolerable public casualty expectation of 30 in a million per launch there is an implied risk profile standard. This risk profile has a probability of 3×10^{-6} per launch of 1 or more through 10 or more casualties and zero probability of greater than 10 casualties.

(3) Similarly, the "excursion to 300 in a million" casualty expectation taken with the allowable probability of 10 or more casualties gives a risk profile with a slope of approximately -1.5.

b. **De Facto Aviation Risks (PL60 Interpretation for ER)**

Risk profiles were estimated for the risk from general aviation and military aircraft during flight phases other than landing and takeoff to the populations placed at risk by ER launch operations. These risk profiles were approximated by two straight line segments: one segment for less than 10 casualties and a second segment for 10 or more casualties. The resulting annual risk profile was scaled to a mission risk profile based on the assumption of 33 launches per year. This results in a risk profile with an associated casualty expectation of approximately 600 in a million. The low casualty portion of the risk profile has a slope of approximately -2, while the high casualty portion of the risk profile has a slope of approximately -7. (No comparable figures are available for WR)

c. **De Facto National Risks**

A de facto national accident *fatality* risk profile was approximated by a straight line. The frequencies of occurrence were scaled from the national population to 100,000 people --

a typical range vicinity population. It was assumed that annual launch operations should be allowed to perturb the scaled profile by no more than 1%. The resulting profile was then scaled by an assumed 33 missions per year to obtain a risk profile "standard" applicable on a per mission basis. The resulting curve has a slope -1.6 and an associated casualty expectation of more than one in a thousand per launch.

d. **Multiple Zones**

Two variations of this approach were presented. Each of them includes four decision zones as defined by three curves. The following characterize the four decision zones:

Accepted. A risk profile falling below the lowest curve is automatically accepted without further review because of the low risk levels.

Mitigation Zone. Risk profiles falling above the lowest curve but below the second curve would generate a review of mission plans to identify candidate mitigations. After review and consideration of potential mitigations, all risk profiles falling within this zone would be accepted.

Commander's Discretion. Risk profiles in this region may be accepted by the commander. Although these risk levels are higher than desirable, excursions to these levels may be accepted when justified by other factors.

Not Accepted by Safety. The catastrophic risk potential in this region is not regarded as acceptable by the Range Safety Directorate.

The three curves are called the **Threshold of Concern,** the **Maximum Generally Acceptable,** and the **Limit of Commander's Discretion.** Both subalternatives use common curves for the **Threshold of Concern,** and the **Maximum Generally Acceptable**. They differ in the construction of the **Limit of Commander's Discretion.**

Both subalternatives define the **Limit of Commander's Discretion** so that the casualty expectation is 300 in a million. The first subalternative defines the **Limit of Commander's Discretion** so that it has an associated casualty expectation of 300 in a million and so that it parallels the **Maximum Generally Acceptable** curve (defined below).

The second alternative uses a set of half decade bands (1-3, 3-10, 10-30, 30-100, etc) to define the **Limit of Commander's Discretion**. The probability levels are set so that the casualty expectation contribution from each band by itself is 30 in a million.

The **Maximum Generally Acceptable** curve begins at the same value as the **Limit of Commander's Discretion** curve for 1 casualty. For small numbers of casualties (less than or equal to 10) the curve has a slope of -1.5 (follows a rule that $f \bullet n^{1.5}$ is a constant). For more than 10 casualties the curve has a slope of -2. (Slopes follow one of the European standards presented at a previous session.)

The **Threshold of Concern** parallels the **Maximum Generally Acceptable** curve at a probability 0.03 as large.

6. *Proposed Method of Incorporating Multiple Levels of Injury in Risk Profiles*

M. Kinna has proposed the following approach to treating multiple levels of injury. In the following discussion "casualty" is defined as any injury (except the most minor) from mild through fatality.

Required Risk Profiles

DEBRIS:
- One profile depicting risk of mild injury through fatality.

BLAST:
- One profile depicting risk of mild injury through fatality.

TOXICS:
- One profile depicting risk of mild injury through fatality.
- One profile depicting only significant/major through fatal injuries. (A subset of "casualties.")

Rationale

Debris: A casualty is anyone who experiences mild injury through fatality. Even mild injuries from debris would have a traumatic effect because of the dramatic nature of the hazard (debris through the roof of a house, secondary debris from nearby impact or explosion, or direct impact of a small fragment). A commander would not want to subject anyone to the hazard of even a mild injury of this nature if avoidable. Neither Safety nor the Air Force would gain credibility by suggesting that a meaningful go/no-go decision could be based on a policy that allows launches to occur when the probability

of mild debris injuries from debris is greater than the criterion for a launch hold based on the probability of debris fatalities. A single risk profile encompassing the probabilities of mild injury through fatality should show what the commander wants to know regarding debris.

Blast: The injury mechanism is shards of glass produced by (distant focus) overpressure. Again, a casualty would be considered anyone who experiences mild injury through fatality as the hazard is just another from of debris. Even mild injuries inflicted under these dramatic circumstances (window blown out, cuts, bleeding) would have great negative impact. A commander would not want to subject anyone to even mild hazards of this nature if avoidable. A single risk profile would provide the needed information.

Toxic: The toxic injury can be a broader spectrum of effects (different for sensitive people, delayed) than the effects from debris and blast. Some effects can be subtle or delayed and some can be immediate and dramatic. A risk profile showing the extent of potential for mild injury would express the level of risk for mild, delayed, subtle effects, affecting everyone within its scope. A second profile should be available to show the range of possibly "dramatic" (immediate, significant, fatal) effects. Use of two profiles for toxic risk assessment would also serve to clarify through use the nature of toxic risk profiles. The mild injury profile would probably be very 'flat' and the profile showing serious injury through death would be "steeper."

Derived Rules

(1) Risks from hazards that are expected to result in predominantly immediate and dramatic effects and where all people are equally vulnerable, will be shown on a single risk profile. (Blast, debris, lasers, fire)

(2) Risks from hazards that are expected to result in many delayed or subtle effects or where all people are not equally vulnerable will be shown using two risk profiles. (Toxics, ionizing radiation) One profile will show risks of all effects, mild through fatal. A second profile will show risks of only those effects that are generally immediate, significant or fatal.

7. *Post-Workshop Developments*

ACTA obtained from a Dutch correspondent an update on more recent developments in the area of risk acceptability in Holland:

Following the October 1992 crash of an El-Al Boeing 747 in a suburb of Amsterdam, the Dutch performed a probabilistic risk assessment of flying activities related to the major International Airport Schiphol. This study revealed that there was a region of elevated risks (approximately 50 km by 50 km) about the airport in which the risks were orders of magnitude higher than had been previously deemed acceptable for stationary installations. Consequently, the Dutch government is developing four different sets of risk acceptability criteria:

1). Stationary Chemical Industries,
2). Nuclear Power Plants,
3). Transport of dangerous materials,
4). ad hoc risk management policy for the Schiphol Airport.

Common features the first three are (1) individual risk criteria of 10^{-6} , (2) the slope of risk profile standards is -2 (*i.e.*, curve is of the form $f \bullet N^2 = \text{constant}$), and (3) *de minimis* levels for societal risk have been eliminated.

Dutch Criteria for Acceptable Risks

ARENA	CRITERIA FOR ACCEPTABLE RISK PROFILES
Chemical Industry	$f \bullet N^2 = 10^{-3}$ per year for prompt fatalities when achievable, otherwise ALARP (as low as reasonably possible)
Existing Nuclear Power Plants	$f \bullet N^2 = 10^{-3}$ per year for prompt fatalities
New Nuclear Power Plants	$f \bullet N^2 = 10^{-5}$ per year
Transport	$f \bullet N^2 = 10^{-1}$ per kilometer per year *(pending)*

Given that the risks around Schiphol airport were considered excessive (4×10^{-3} per year for 10 or more prompt fatalities and 1×10^{-4} for 100 or more prompt fatalities), the Dutch are seeking to reduce the risk by pulling down housing within the highest risk contours and putting a moratorium on future construction and the addition of any other hazardous industries to the area.

8. *Recommendations*

When risk profiles were introduced it was demonstrated that there are an infinite number of risk profiles having a specified casualty expectation. A catastrophe averse policy is characterized by an acceptable risk profile standard with a slope less than -1. Consequently, the working group concluded at an earlier session that the as-yet-to-be-defined standard must have a slope less than -1 for large numbers of casualties.

During the last several workshops a number of European standards have been discussed. Workshop participants also reviewed two de facto risk profiles (aviation risk, PL60, and all U.S. accident risk). All existing standards use a slope of -2 for 10 or more casualties. One standard uses a slope of -1.5 for fewer than 10 casualties. The only standard to address lesser injuries (Gronigen) uses a slope of -1 for lesser injuries until their number is sufficient to be "equivalent" to one fatality.

The de facto U. S. accident risk profile (fatalities) has a slope of -1.6. The aviation risk profile has a slope of approximately -2 for 9 or fewer casualties and approximately -7 for 10 or more casualties. The high casualty portion of this curve has a steep slope as a result of the limited casualty area of general aviation aircraft. (General aviation aircraft are the major contributors to the risk profile.) Thus, only the low casualty portion of this curve should be considered in contemplating a risk profile standard.

Based on the foregoing observations, ACTA offers the following recommendations:

Acceptable Risk Profile Standards:

The 1990 safety collective and catastrophic risk objectives should be put into a risk profile format with the following attributes:

(a) The area under the risk profile (collective casualty expectation) must satisfy the expected collective risk criterion.

Casualties (Severe Injuries or Fatalities)

(b) The absolute value of the slope of the risk profile standard should be no less than 1.5 for less than 10 casualties.

(c) The absolute value of the slope of the risk profile standard should be no less than 2 for 10 or more casualties.

Mild Injuries

(d) The absolute value of the slope of the risk profile should be no less than 1 for less than 10 injuries.

(e) The absolute value of the slope of the risk profile standard should be no less than 1.5 for 10 or more casualties.

Provisional Implementation

The standards for the four categories listed in section 6 should be as follows:

Debris:	Straight line with a slope of -2.
Blast:	Straight line with a slope of -2.
Toxic (Mild or Worse):	Two straight line segments. The first segment is for less than 10 casualties; this line segment has a slope of -1.5. The second segment applies to 10 or more casualties and has a slope of -2.
Toxic (Severe/Fatal):	Straight line with a slope of -2.
All Hazards (Severe/Fatal):	Straight line with a slope of -2.

Space Shuttle Risks

It is clear the Space Shuttle risks significantly exceed any standard discussed or considered in the workshop. In addition, the societal risks for each Space Shuttle launch **exceeds the levels that the Dutch found *unacceptable* on an annual basis** for the operation of the Schiphol airport.

9. *Pending Issues*

- Acceptance of the recommendations presented in items 6 and 8.
- Establishing a policy regarding the management of aggregate risks from all hazards.
- Establishing a policy to assure that annual risk remains acceptable.
- Establishing acceptable risk standards for the special problems posed for toxic risks.
- Determining how confidence bounds on casualty expectation and risk profiles should be used in the decision process.

- Determination of an appropriate treatment for different classes of susceptible populations.

- Determination of the appropriate risk profile standard for mission essential workers given a standard for the general public.

ACCEPTABLE RISK WORKSHOP

MAY 18, 1994

ACTA Inc

ACCEPTABLE RISK WORKSHOP AGENDA

RECAP AND REVIEW OF PAST AGREEMENTS

TREATMENT OF MULTIPLE HAZARDS AND MULTIPLE LEVELS OF INJURY

RISK PROFILE STANDARDS

REAL TIME DECISION CRITERIA

ACCEPTABLE RISK WORKSHOP AGENDA

RECAP AND REVIEW OF PAST AGREEMENTS

TREATMENT OF MULTIPLE HAZARDS AND MULTIPLE LEVELS OF INJURY

RISK PROFILE STANDARDS

REAL TIME DECISION CRITERIA

AGREEMENT REGARDING ACCEPTABLE RISK
(August 1990, 30 SW & 45 SW)

- INDIVIDUAL RISK OF SERIOUS INJURY OR DEATH LEVEL OF 1×10^{-6} PER YEAR FOR ANY MEMBER OF THE GENERAL PUBLIC
- COLLECTIVE "CASUALTY" RISK LEVEL OF 30×10^{-6} PER LAUNCH TO THE GENERAL PUBLIC
- "CASUALTY" NOT EXPLICITLY DEFINED. IN CONTEXT TREATED AS SERIOUS INJURY OR DEATH

PERTINENT RANGE POLICIES
(ERR 127-1)

"ER WILL STRIVE TO ENSURE THAT THE RISK TO THE *GENERAL PUBLIC* AND *FOREIGN COUNTRIES* FROM RANGE OPERATIONS

(1) DOES NOT EXCEED THE RISK TO THE *GENERAL PUBLIC* FROM ALL NATURAL CAUSES AND

(2) MEET THE CRITERIA ESTABLISHED IN PL60."

AGREEMENTS FROM LAST WORKSHOP

- ACCEPTABLE RISK STANDARDS SHOULD BE APPLIED *BOTH* ON A HAZARD BY HAZARD BASIS AND TO TOTAL RISK
- A CONSISTENT SYSTEM OF CATEGORIZING INJURIES SHOULD BE DEVELOPED SO THAT A MILD TOXIC INJURY IS AS BAD AS A MILD BLAST INJURY OR DEBRIS INJURY
- A WEIGHTING SCHEME SHOULD BE DEVELOPED TO RELATE LEVELS OF INJURY
- ACCEPTABLE RISK STANDARDS MUST BE EXPRESSIBLE ON A PER MISSION BASIS FOR OPERATIONAL USAGE AND ON AN ANNUAL BASIS FOR COMMUNICATION WITH THE GENERAL PUBLIC
- RISK PROFILE STANDARDS MUST BE ESTABLISHED SEPARATELY FOR THE POPULATION VOLUNTARILY ASSUMING RISK FROM THOSE INVOLUNTARILY ASSUMING RISK

UNFINISHED BUSINESS: WHAT IS A CASUALTY?

- IMMEDIATE FATALITY ONLY
- IMMEDIATE OR DELAYED FATALITY
- IMMEDIATE OR DELAYED FATALITY, OR SEVERE INJURY

ACCEPTABLE RISK CRITERIA THAT ARE NEEDED

- EXPECTED COLLECTIVE RISK PER LAUNCH
  (LESSER INJURIES, ASSUMING AN AGREED CASUALTY DEFINITION)

- RISK PROFILES
  (RISK PROFILES DEPICT ALL RISK LEVELS INCLUDING CATASTROPHIC RISK)

- REAL TIME DECISION CRITERIA

ACCEPTABLE RISK WORKSHOP AGENDA

RECAP AND REVIEW OF PAST AGREEMENTS

TREATMENT OF MULTIPLE HAZARDS AND MULTIPLE LEVELS OF INJURY

RISK PROFILE STANDARDS

REAL TIME DECISION CRITERIA

MULTIPLE HAZARDS

RISK FROM EACH HAZARD IS MANAGED SEPARATELY

HIDDEN ASSUMPTION:

- RISKS FOR ANY SINGLE LAUNCH ARE DOMINATED BY A SINGLE HAZARD

NOT ALWAYS TRUE, THERE IS A PARTICULAR CONCERN REGARDING RISK PROFILES

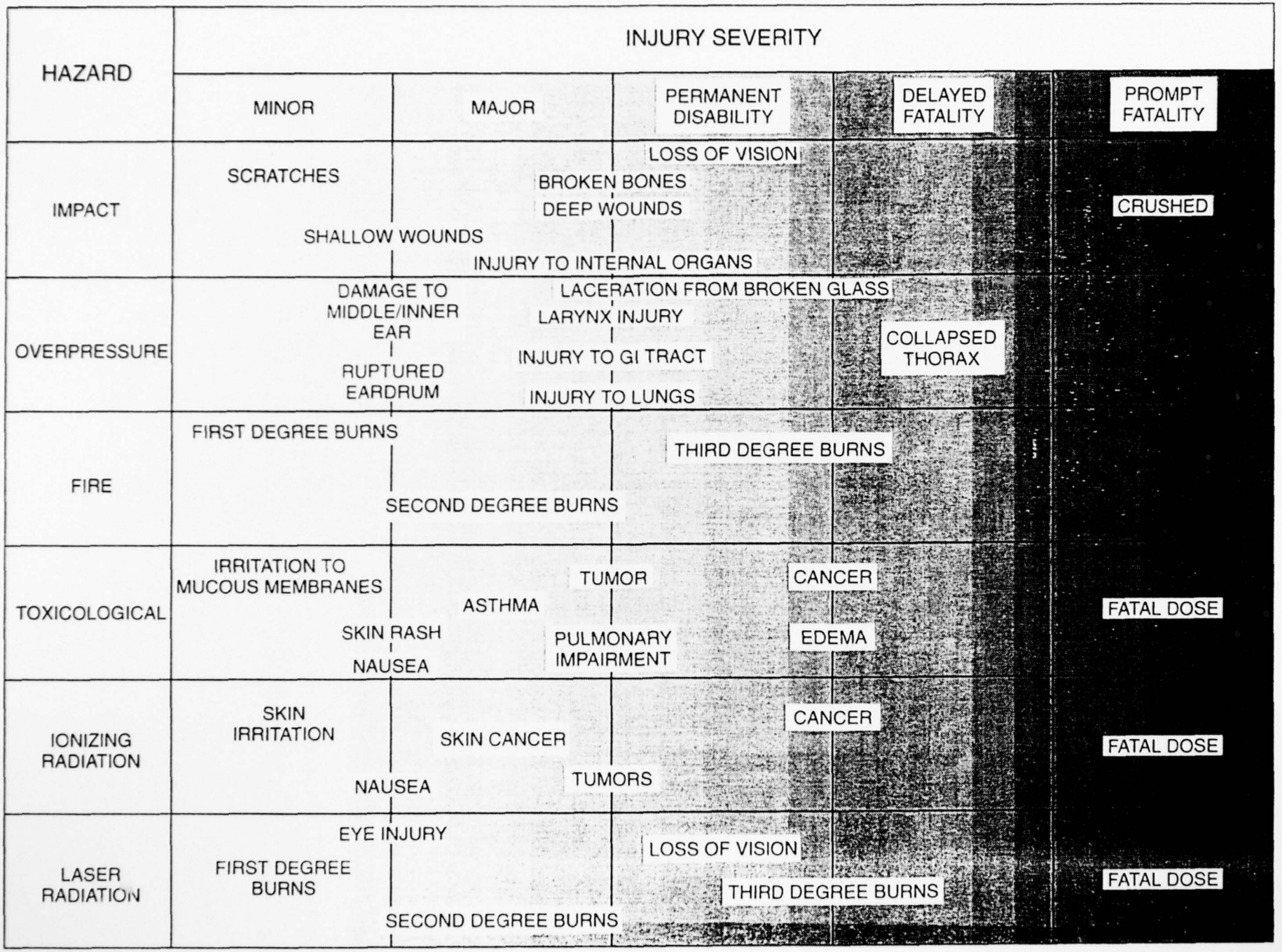
CONCLUSION:

- MUST BE ABLE TO EXAMINE COMBINED RISKS
- MUST HAVE INJURY SEVERITY "COMPARABLE" ACROSS HAZARDS

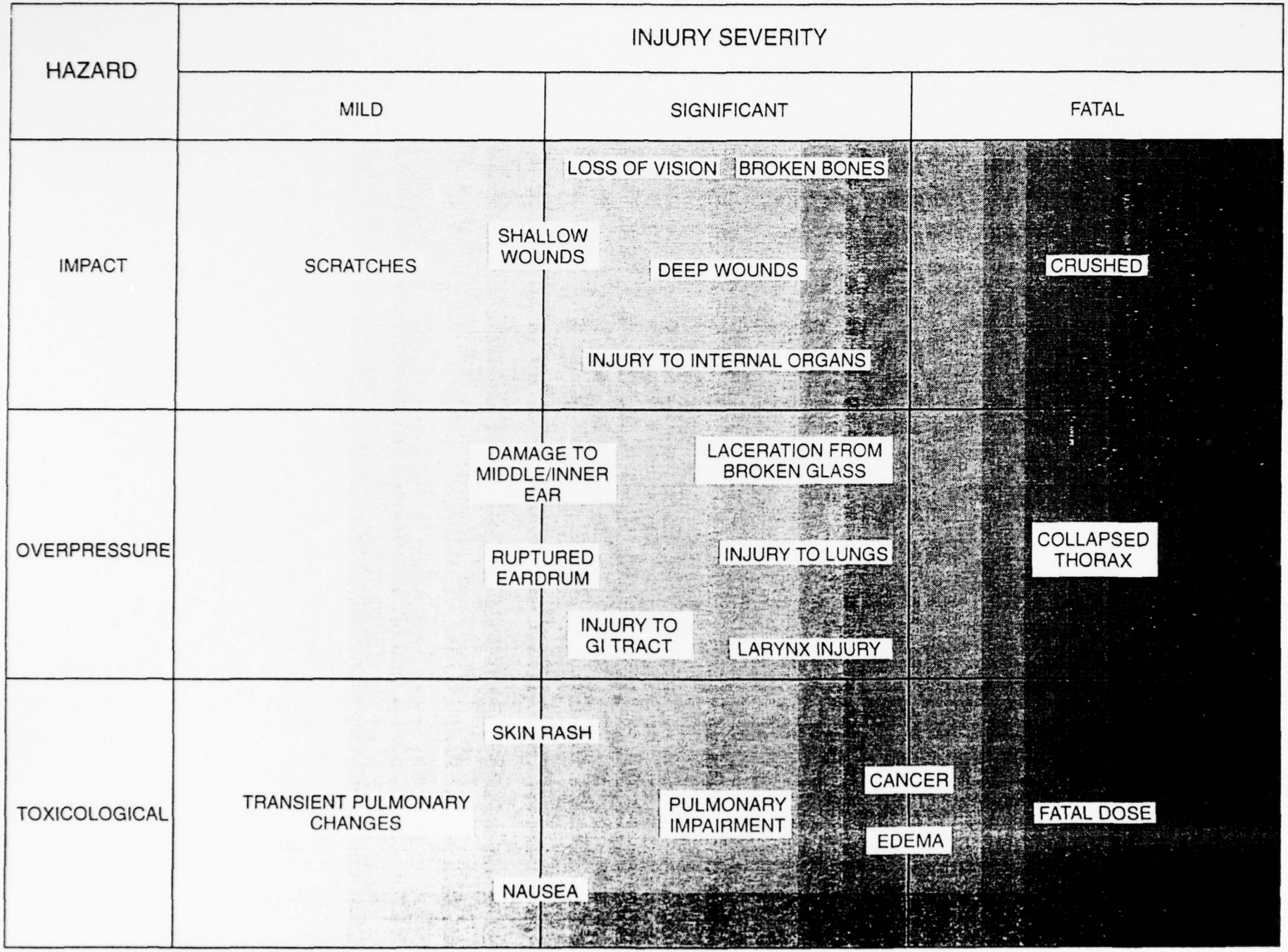
LEVELS OF INJURY

- COMPARABILITY OF LEVELS ACROSS HAZARDS
  - ORIGINAL MATRIX
  - MATRIX USED IN SURVEY
  - SURVEY RESULTS
  - TRIAGE
- COMPARABILITY OF LEVELS OF INJURY WITH EACH OTHER
  - CONTEXT FOR ANALYSIS
  - SURVEY RESULTS
  - NEW INFORMATION TO ASSIST IN FORMULATING ANSWERS

SEVERITY OF INJURY BY HAZARD



SEVERITY OF INJURY BY HAZARD
(REDUCED SET OF INJURY SEVERITIES)



SURVEY RESULTS: INJURY SEVERITY MATRIX

HAZARD	INJURY SEVERITY		
	MILD	SIGNIFICANT	FATAL
IMPACT	SCRATCHES ABRASIONS MILD BURNS HEAD ACHE SHALLOW WOUNDS	BROKEN BONES DEEP WOUNDS LOSS OF VISION LOSS OF HEARING SEVERE BURNS SEVERED LIMBS CONCUSSION HEART ATTACK SIGNIFICANT INJURY TO INTERNAL ORGANS	CRUSHED FATAL BRAIN SWELLING
OVERPRESSURE	RUPTURED EARDRUM RINGING EARS TEMPORARY LOSS OF HEARING FALLING INJURY	LACERATION FROM BROKEN GLASS INJURY TO GI TRACT LARYNX INJURY INJURY TO LUNGS DAMAGE TO MIDDLE/INNER EAR HEART ATTACK	COLLAPSED THORAX FATAL CONCUSSION
TOXICOLOGICAL	TRANSIENT PULMONARY CHANGES SKIN RASH NAUSEA	PULMONARY IMPAIRMENT EDEMA CURABLE CANCER HEART ATTACK LOSS OF VISION EYE AND MUCOSA SCORING CANCER IN REMISSION	FATAL DOSE METASTASIZED INOPERABLE CANCER

ACTA Inc

TRIAGE

DEFINITION:

THE PROCESS OF "SORTING" CASUALTIES ACCORDING TO URGENCY OF MEDICAL CONDITION SO PRIORITIES CAN BE ESTABLISHED FOR TREATMENT AND EVACUATION.

PRINCIPLES OF TRIAGE:

THE PRINCIPAL MECHANICAL DANGERS WHICH THREATEN LIFE AFTER WOUNDING ARE ASPHYXIA AND HEMORRHAGE.

THE SALVAGE OF LIFE TAKES PRECEDENCE OVER THE SALVAGE OF LIMB.

THE PRESERVATION OF FUNCTION TAKES PRECEDENCE OVER THE CORRECTION OF ANATOMIC DEFECT.

TRIAGE IS PERFORMED TO ENSURE MAXIMUM UTILIZATION OF PERSONNEL, SUPPLIES AND FACILITIES AND TO ENSURE THE LEAST POSSIBLE DELAY IN EVACUATION AND THERAPY.

EFFECTIVE TRIAGE RESTORES NEEDED MANPOWER BY DECREASING MORBIDITY AND MORTALITY TO THE LOWEST DEGREE POSSIBLE

TRIAGE CATEGORIES

CATEGORIES	MINIMAL (AMA Priority 1)	IMMEDIATE (AMA Priority 2)	DELAYED (AMA Priority 3)	EXPECTANT (AMA Priority 4)
DEFINITIONS	REQUIRES MINOR PROFESSIONAL TREATMENT ON AN AMBULATORY BASIS	LIFE THREATENING CONDITIONS OR MODERATE INJURIES TREATABLE WITH MINIMAL TIME, PERSONNEL AND SUPPLIES	MAY HAVE DEFINITIVE TREATMENT DELAYED WITHOUT SIGNIFICANT JEOPARDY TO ULTIMATE RECOVERY	REQUIRE EXTENSIVE THERAPY BEYOND AVAILABLE MEANS
EXAMPLES	• SMALL LACERATION OR CONTUSIONS • CLOSED FRACTURES OF SMALL BONES • 2nd DEGREE BURNS OF LESS THAN 20% OF THE BODY & NOT INCLUDING THE FACE,HANDS OR FEET	• MECHANICAL CAUSES OF RESPIRATORY OBSTRUCTION • PNEUMOTHORAX, MAXILLOFACIAL WOUNDS IN WHICH ASPHYXIA EXITS OR IS LIKELY • HEMORRHAGE FROM AN ACCESSIBLE SITE • OPEN FRACTURES OF MAJOR BONES	• VISCERAL INJURIES • WOUNDS OF ABDOMEN & URINARY TRACT • BURNS OF HANDS, FEET, GENITALIA, PERINEUM • MODERATE LACERATIONS WITHOUT BLEEDING • CLOSED FRACTURES OF MAJOR BONES • NON-CRITICAL CNS* INJURIES • 2nd DEGREE BURNS OF 20-40% OF THE BODY	• CRITICAL RESPIRATORY & CNS INJURIES • SEVERE MULTIPLE BURNS OF OVER 40% OF THE BODY
RELATIVE SEVERITY	1	3	2	4

** CENTRAL NERVOUS SYSTEM*

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ISSUE: BASIS FOR ACCEPTABLE RISK FOR LESSER INJURIES

- MUST BE "CONSISTENT" WITH RANGE SAFETY'S ADOPTED STANDARDS

- MUST BE DEFENSIBLE

OVERVIEW OF INJURY SEVERITY MODELING

	DEBRIS[1]	BLAST[2]	TOXIC[3]
LEVELS CALCULATED	SIGNIFICANT, FATAL INJURIES	CASUALTY	MILD, SIGNIFICANT, FATAL INJURIES
MODELING CAPABILITY	FATAL, SIGNIFICANT, OTHER LEVELS (?)	FATAL, SIGNIFICANT, OTHER LEVELS (?)	FATAL, SIGNIFICANT, MILD INJURIES
MODELED THREAT	DIRECT IMPACT STRUCTURAL DAMAGE ΔP (FIRE NOT MODELED)	GLASS SHARDS	TOXIC GAS
POPULATION VULNERABILITY	ALL PEOPLE EQUALLY VULNERABLE STRUCTURE TYPE GOVERNS • PROTECTION • THREAT	ALL PEOPLE EQUALLY VULNERABLE STRUCTURE TYPE GOVERNS • PROTECTION • THREAT	HUMAN VULNERABILITY MODELED (NORMAL, CHILDREN, BRONCHITICS, AGED) STRUCTURE TYPE GOVERNS PROTECTION

(1) MULTIPLE LEVELS NOT IN CERTIFIED VERSION OF LARA MODELING OF LESSER INJURIES MOST FEASIBLE FOR EFFECT OF ΔP ON UNPROTECTED PEOPLE

(2) CURRENT VERSION PRODUCES SEVERE INJURIES

(3) CURRENT LATRA; NOT YET CERTIFIED

KEY OBSERVATION: INJURY SEVERITY

ONLY TOXIC, WITH LATRA, IS CURRENTLY USING

LEVELS OF SEVERITY

WHY CHANGE BLAST & DEBRIS INJURY LEVEL CALCULATIONS?

ONE INJURY LEVEL FORCES ONE OF TWO MODELING ALTERNATIVES:

- **NEGLECT ALL LESSER INJURIES (UNCONSERVATIVE)**
- **TREAT LESSER INJURIES AS CASUALTIES (POSSIBLY UNDUE CONSTRAINT OF OPERATIONS)**

STRATEGIES FOR VALUING AN INJURY

- OPINION: RANGE SAFETY ANALYSTS SURVEY
- IMPACT ON FUTURE RANGE OPERATIONS
- DOLLAR VALUE OF WORKERS COMP. CLAIM FOR INJURY LEVEL
- DE FACTO RELATIVE FREQUENCIES OF INJURY LEVELS ("REVEALED" RELATIVE RISK)
- ESTIMATE OF TOTAL ECONOMIC VALUE

SURVEY RESULTS (CRITERIA BASED ON OPINION)

QUESTION:

X MILD INJURIES = Y SIGNIFICANT INJURIES = 1 FATALITY

GENERAL:

- AUGMENT WEIGHTING SCHEME. ASSURE RESULTS AT EACH INJURY LEVEL AVAILABLE TO DECISION MAKER

- TWO RESPONDENTS UNCOMFORTABLE WITH RELATIVE WEIGHTS

- APPROXIMATELY 2/3 RESPONSES:
  100 MILD = 10 SIGNIFICANT = 1 FATALITY

- APPROXIMATELY 1/3 RESPONSES
  1000 - 3000 MILD = 1 FATALITY

IMPACT ON FUTURE OPERATIONS

BASELINE ADVERSE RESULT: 1 FATALITY

- **IF "TEN" PEOPLE WERE SIGNIFICANTLY INJURED, WOULD GENERAL ASSESSMENT BE THAT IT WAS "LUCK" NO ONE WAS KILLED?**

- **IF "TEN" PEOPLE EXPERIENCED MILD INJURIES, WERE WE LUCKY THAT NO ONE WAS SIGNIFICANTLY INJURED? . . . KILLED?**

- **IF THE ENTIRE CITY OF LOMPOC SUFFERS MILD COUGHING AND TRANSIENT PULMONARY CHANGES, WILL THE REACTION OF CONGRESS BE COMPARABLE TO THEIR REACTION TO A SINGLE FATALITY?**

COST OF INJURIES
(1984 WORKERS COMPENSATION STATISTICS)

INJURY LEVEL	MEAN CLAIM PAYMENT	E (INJURY LEVEL) / E (DEATH)
DEATH	$ 60,000	1.
PERMANENT TOTAL DISABILITY	$ 655,100	11.
MAJOR PERMANENT DISABILITY	$ 53,500	.89
MINOR PERMANENT DISABILITY	$ 9,900	.16
TEMPORARY DISABILITY	$ 1,500	0.25
MEDICAL ONLY	$ 170	.003

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[redacted]97/4[redacted]Y 18[redacted]WOR[redacted]P-25[redacted]

RELATIVE FREQUENCY[1] OF ACCIDENT INJURY LEVELS

ACCIDENT CATEGORY	DEATHS[3] Disabling Injuries[2, 3] Nonfatal	DEATHS[3] Non-Disabling Injuries[4]
ALL ACCIDENTS	0.005	0.002
ACCIDENTS AT WORK	0.003	NA
ACCIDENTS AT HOME	0.003	0.002

SOURCE: ACCIDENT FACTS 1993

1 SOME INDICATION OF THE STABILITY OF THESE RATIOS CAN BE OBTAINED FROM THE DEATH-TO-INJURY RATIOS FOR RAIL ACCIDENTS BETWEEN 1963 AND 1992. THESE RANGE FROM 0.03 TO 0.11

2 DISABLING INJURIES ARE ONES RESULTING IN DEATH, SOME PERMANENT DISABILITY, OR RENDERS THE INJURED PERSON UNABLE TO EFFECTIVELY PERFORM THEIR REGULAR DUTIES OR ACTIVITIES FOR A FULL DAY BEYOND THE DAY OF INJURY

3 1992 STATISTICS

4 1991 STATISTICS

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TOTAL ECONOMIC VALUE

IMMEDIATE RESPONSE COSTS - NONMEDICAL, e.g. AMBULANCE

SHORT TERM EMERGENCY MEDICAL CARE: 0 - 1 WEEK

MIDDLE TERM MEDICAL CARE: 1 WEEK - 5 YEARS

LONG TERM MEDICAL CARE: 5 YEARS TO END OF LIFE

LOST WAGES

LOST PRODUCTIVITY OR OTHER COSTS

LITIGATION

IMPAIRMENT OF RANGE OPERATIONS

RATIOS FOR TOTAL ECONOMIC VALUE APPROACH

INJURY LEVEL	COST	RATIO OF COST TO DEATH COST
DEATH	$1.E8	1
PERMANENT TOTAL DISABILITY	$1.E8	1
MAJOR PERMANENT DISABILITY	$1.E7	0.1
MINOR PERMANENT DISABILITY	$1.E6	0.01
TEMPORARY DISABILITY	$2.E5	0.002
MEDICAL ONLY	$2.E3	0.00002

CANDIDATE CONCLUSION

- CANNOT DISCRIMINATE BETWEEN CONSEQUENCE OF SIGNIFICANT INJURY AND DEATH

- ~ 1000 MILD INJURIES = 1 DEATH

ACCEPTABLE RISK WORKSHOP AGENDA

RECAP AND REVIEW OF PAST AGREEMENTS

TREATMENT OF MULTIPLE HAZARDS AND MULTIPLE LEVELS OF INJURY

RISK PROFILE STANDARDS

REAL TIME DECISION CRITERIA

RISK PROFILE STANDARDS
SOME CONSIDERATIONS

NUMBER OF ZONES: SINGLE CURVE NOT TO BE EXCEEDED VS MULTIPLE CURVES - ZONES OF UNDESIRABILITY

BASIS OF CURVES(S)

- MATCH SOME LEVEL OF E_C OR ΔE_C
- BASIS FOR CURVE SLOPE/SHAPE
  - RELATED TO SOME STANDARD
  - RELATED TO SOME DE FACTO LEVEL
  - RELATED TO ASPIRATION
  - CATASTROPHE AVERSE: SLOPE < -1

ALTERNATIVE NO. 1 ASPIRATION FOR SAFETY (1990)

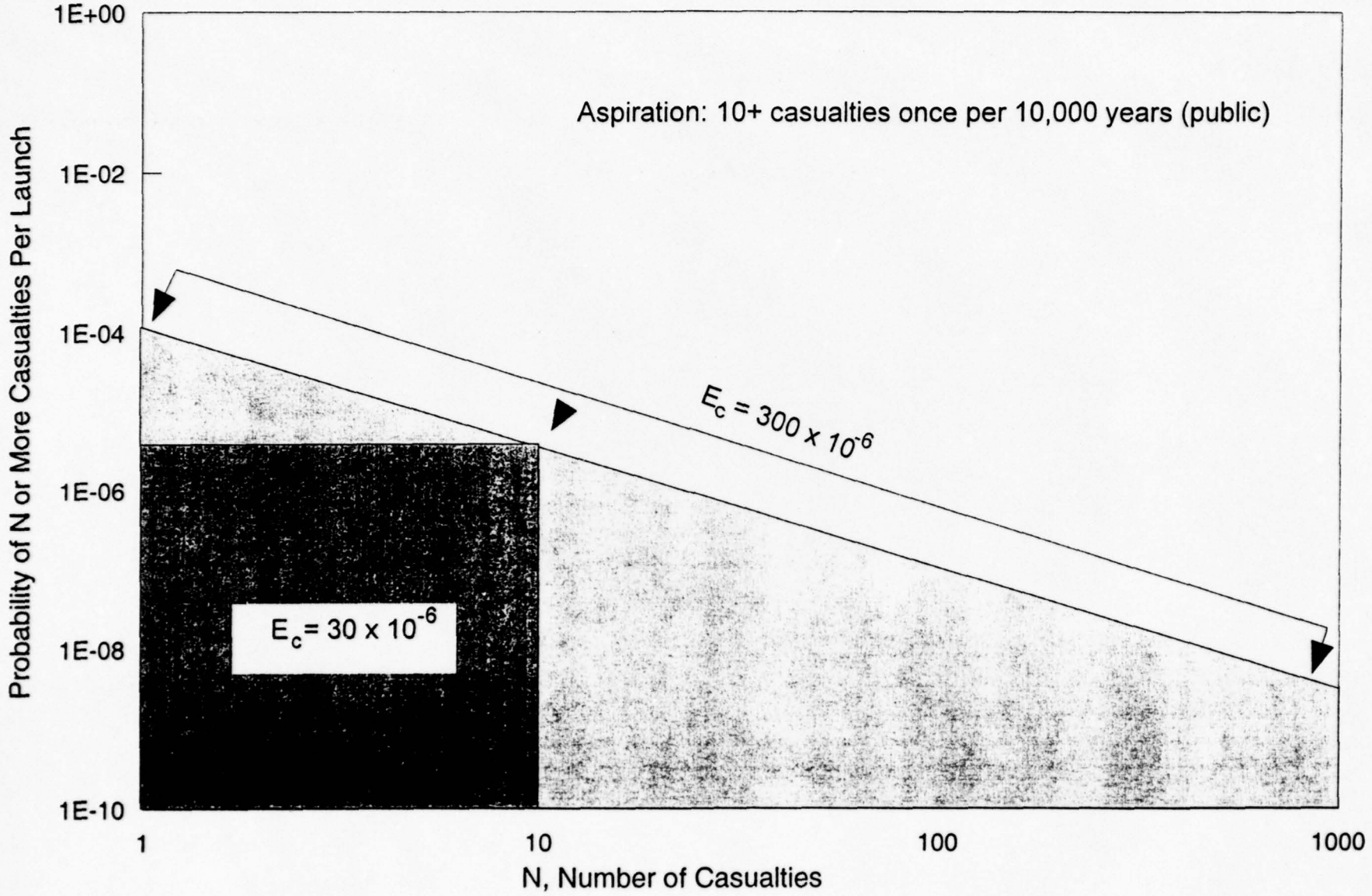
1990 ACCEPTABILITY WORKSHOP

". . . AN ACCIDENT CAUSING **AT LEAST TEN SIMULTANEOUS FATALITIES OR MAJOR INJURIES** TO THE WORK FORCE SHOULD OCCUR **LESS OFTEN THAN ONCE PER THOUSAND YEARS**. GIVEN 33 LAUNCHES PER YEAR (BOTH RANGES) CONTRIBUTING TO THE "BANK" . . . THE PUBLIC IS RESTRICTED TO TEN TIMES LESS RISK THAN THE WORK FORCE . . . WHICH WOULD LEAD US TO A CRITERION OF 30 IN A MILLION PER LAUNCH. EXCURSIONS TO 300 IN A MILLION COULD BE ALLOWED WHEN JUSTIFIED BY OTHER FACTORS."

KEY POINTS

- 10^{+} PUBLIC CASUALTIES/LAUNCH SHOULD HAVE PROBABILITY OF 3×10^{-6} ($0.1 \times 3 \times 10^{-5}$ ALLOWED TO WORK FORCE)
- E_C PER LAUNCH TO WORK FORCE SHOULD BE $< 300 \times 10^{-6}$
- E_C PER LAUNCH TO PUBLIC SHOULD BE $\sim 30 \times 10^{-6}$
- E_C PER LAUNCH TO PUBLIC MAY BE AS HIGH AS 300×10^{-6} WHEN JUSTIFIED

ALTERNATIVE 1: ASPIRATION FOR SAFETY



APPROACH NUMBER 2: DE FACTO AVIATION RISKS (PL60 INTERPRETATION)

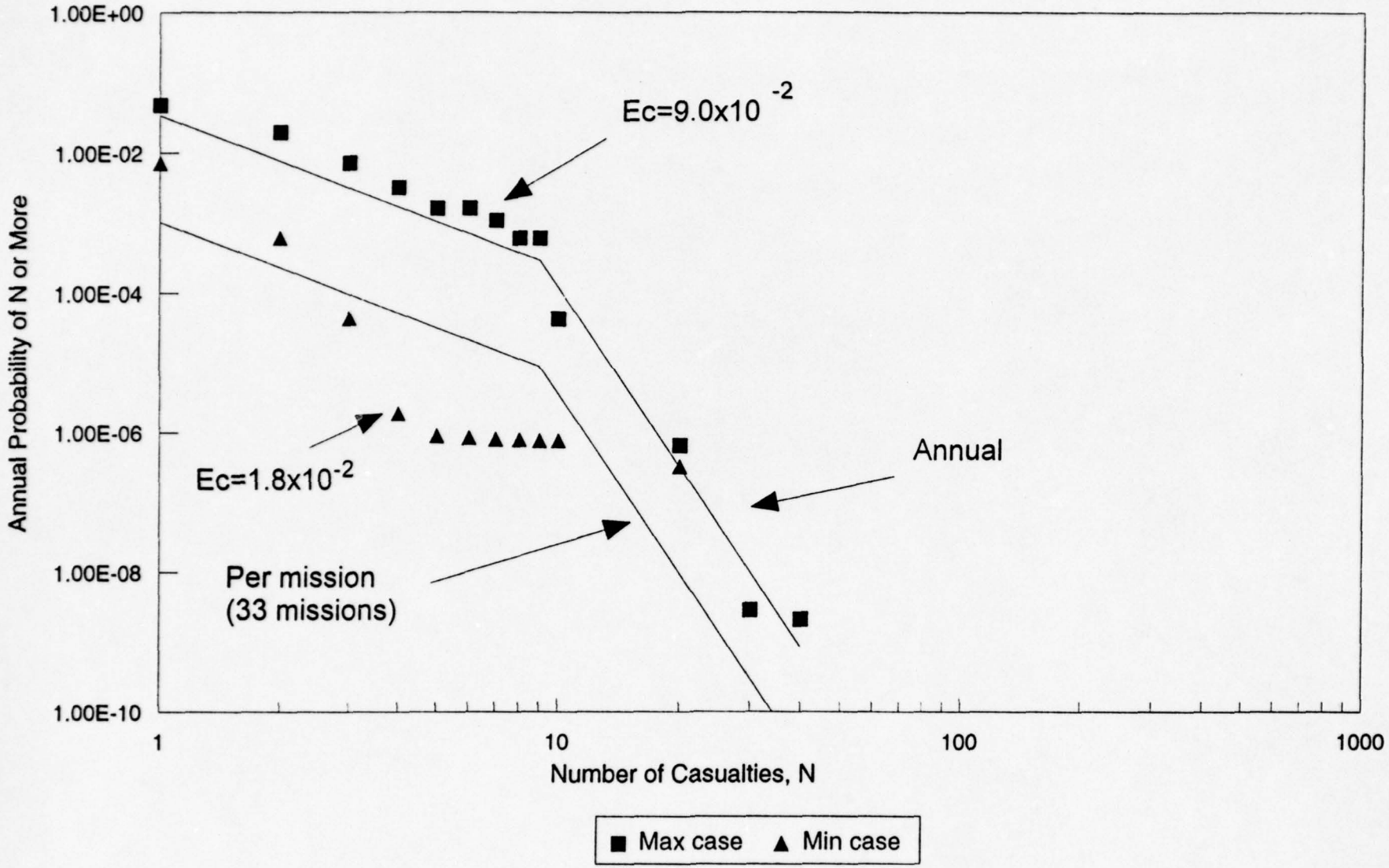
BASELINE:

- RISK PROFILE ESTIMATES FOR COMBINED MILITARY AND GENERAL AVIATION TO POPULATION IN AREA OF CONCERN SURROUNDING CCAFS

PROCEDURE:

- STRAIGHT LINE APPROXIMATION TO CALCULATED ANNUAL RISK PROFILES
- SCALE STRAIGHT LINE APPROXIMATION TO TRAFFIC LEVEL

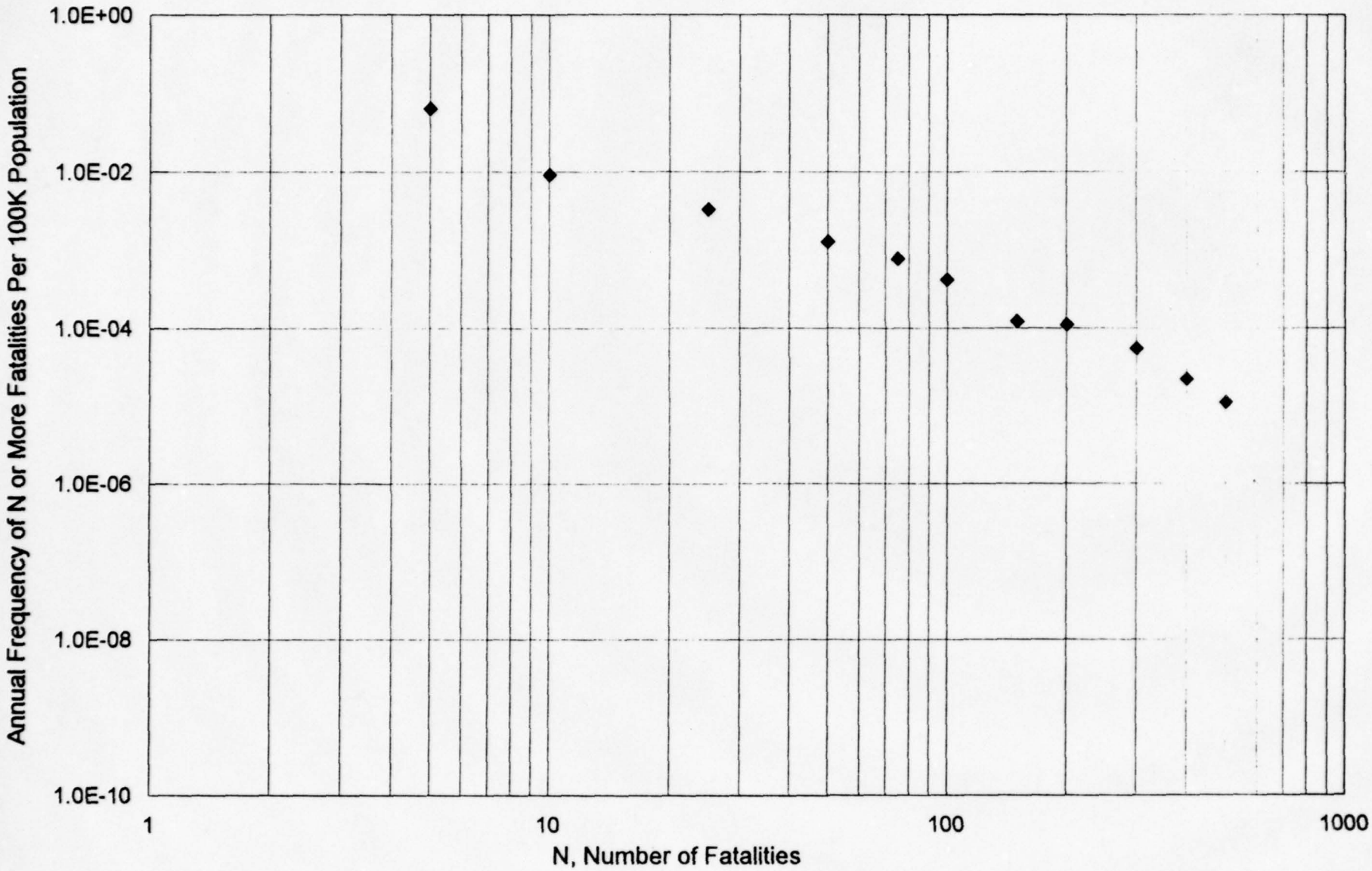
ALTERNATIVE 2: LIMIT BASED ON DE FACTO AVIATION RISKS NEAR CCAFS (PL60 INTERPRETATION)



APPROACH NUMBER 3: DE FACTO NATIONAL RISKS

- KEY MAXIMUM TOLERABLE TO DE FACTO U.S. RISK PROFILE (FATALITIES)
- SCALE FREQUENCIES OF OCCURRENCE FROM U.S. POPULATION TO 100,000 - TYPICAL RANGE VICINITY POPULATION
- ALLOW LAUNCH OPERATIONS TO PERTURB SCALED PROFILE BY NO MORE THAN 1% (CRITICAL ASSUMPTION)
- SCALE BY NUMBER OF MISSIONS PER YEAR (SAY 33)

DE FACTO U.S. RISK PROFILE NORMALIZED TO 100K PEOPLE



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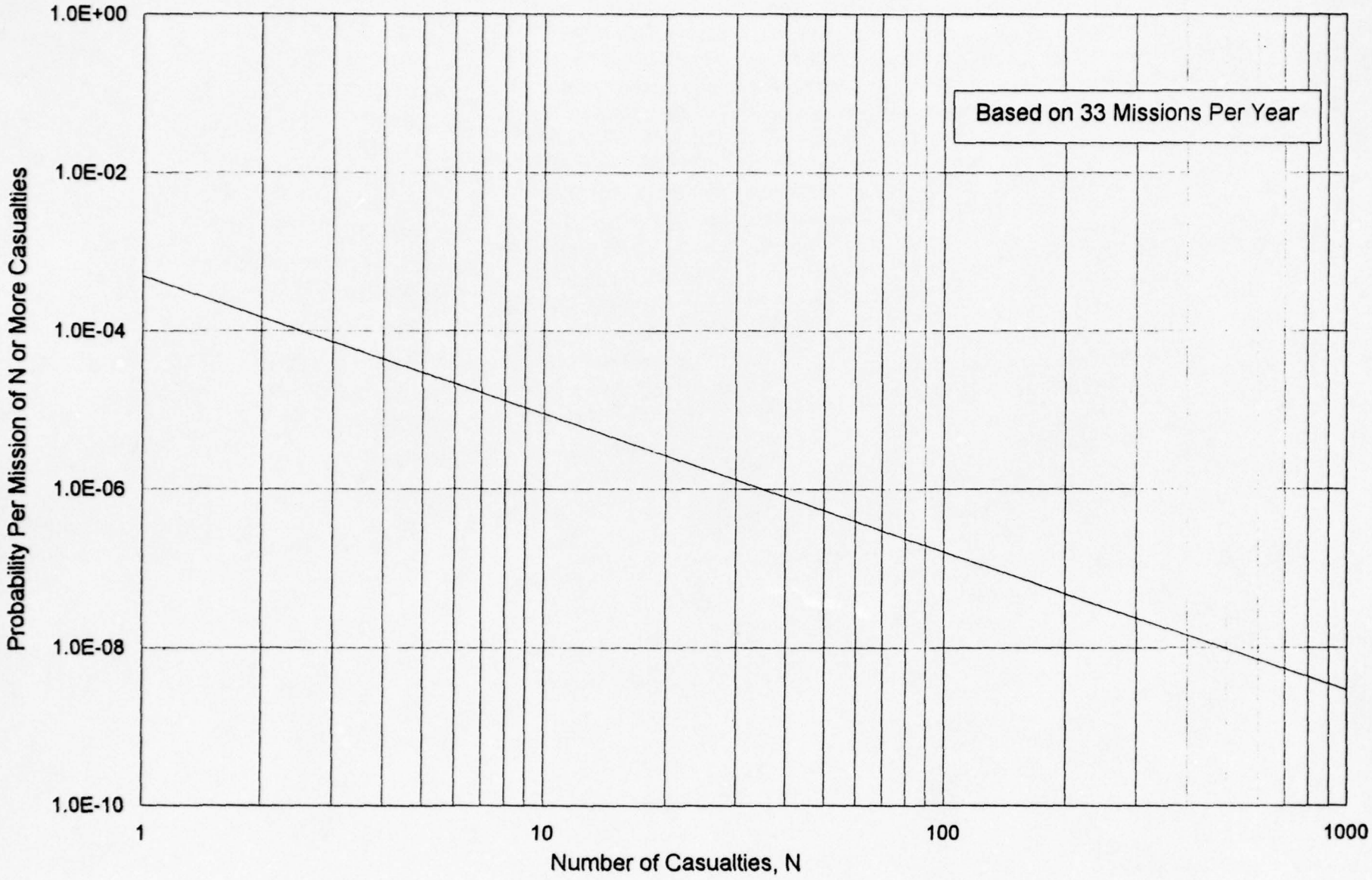
APPROACH 3: MAXIMUM TOLERATED RISK PER LAUNCH BASED ON DE FACTO U.S. RISK PROFILE



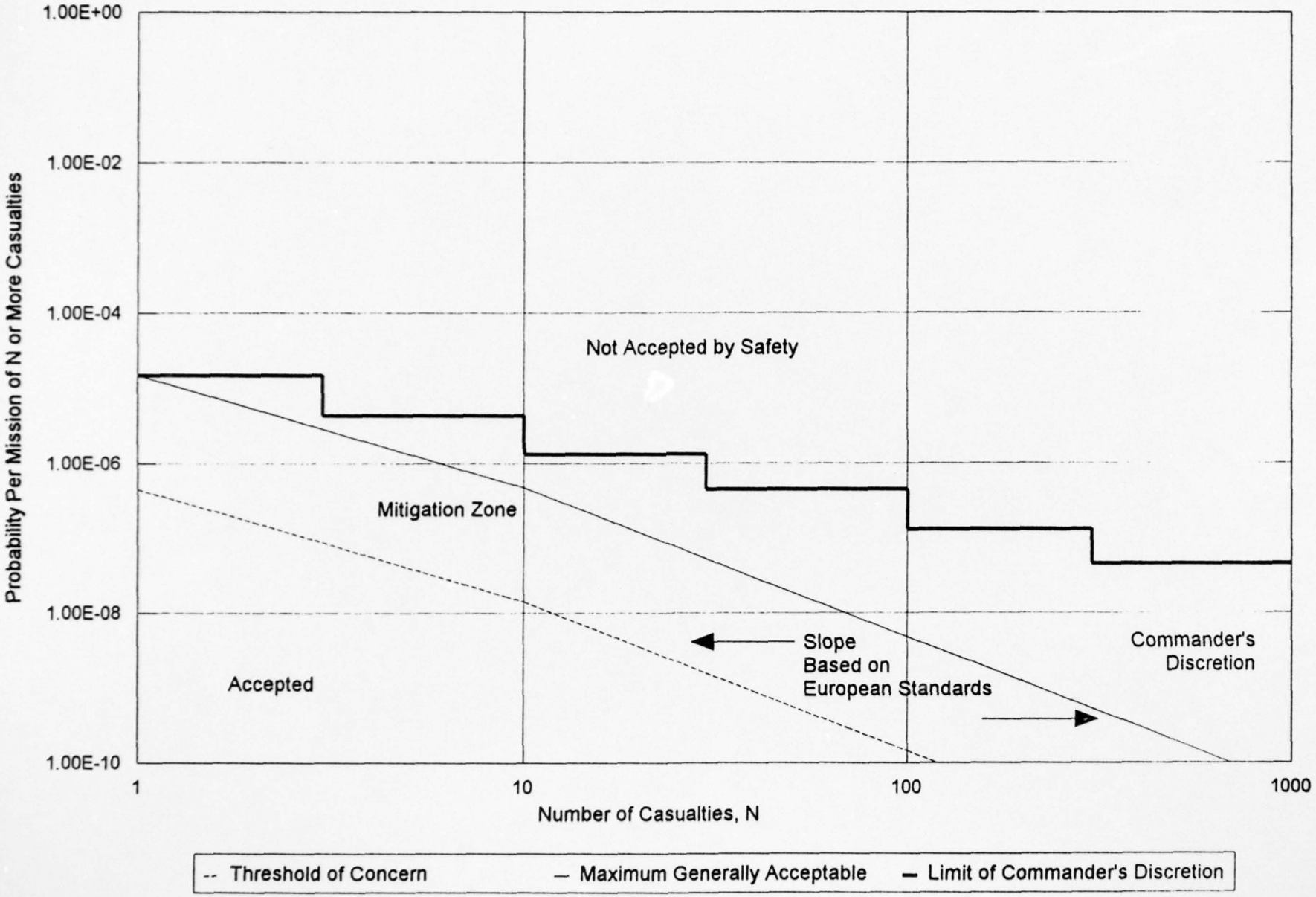
ALTERNATIVE NO. 4: MULTIPLE ZONES

- THREE CURVES CREATE FOUR ZONES
  - ACCEPTED - RISK LEVELS DO NOT WARRANT FURTHER REVIEW
  - MITIGATION ZONE - RISK LEVELS GENERALLY ACCEPTABLE; SUFFICIENTLY HIGH TO JUSTIFY REVIEW AND MITIGATION
  - COMMANDER'S DISCRETION
    - RISK PROFILES IN THIS REGION MAY BE ACCEPTED BY THE COMMANDER, CATASTROPHIC RISK POTENTIAL IS LARGER THAN DESIRABLE
  - NOT ACCEPTED BY SAFETY
    - CATASTROPHIC RISK POTENTIAL NOT REGARDED AS ACCEPTABLE

ALTERNATIVE NO. 4 (CONTINUED)

- LIMIT OF COMMANDER'S DISCRETION:
  - SET OF HALF DECADE (1-3, 3-10, 10-30, 30-100, etc) BANDS
  - OVER EACH BAND PROBABILITY IS SET SO THAT BAND BY ITSELF HAS AREA EQUAL TO 30×10^{-6}
  - $E_C = 300 \times 10^{-6}$
- MAXIMUM GENERALLY ACCEPTABLE:
  - CURVE BEGINS AT THE SAME VALUE AS THE LIMIT OF COMMANDER'S DISCRETION CURVE FOR 1 CASUALTY
  - FOR 1 -10 CASUALTIES FOLLOWS $F \bullet N^{1.5}$ RULE
  - FOR 10^+ CASUALTIES FOLLOWS $F \bullet N^2$ RULE
- THRESHOLD OF CONCERN
  - PARALLELS "MAXIMUM GENERALLY ACCEPTABLE CURVE" AT A PROBABILITY 0.03 AS LARGE

APPROACH 4: BANDS OF ACCEPTABILITY



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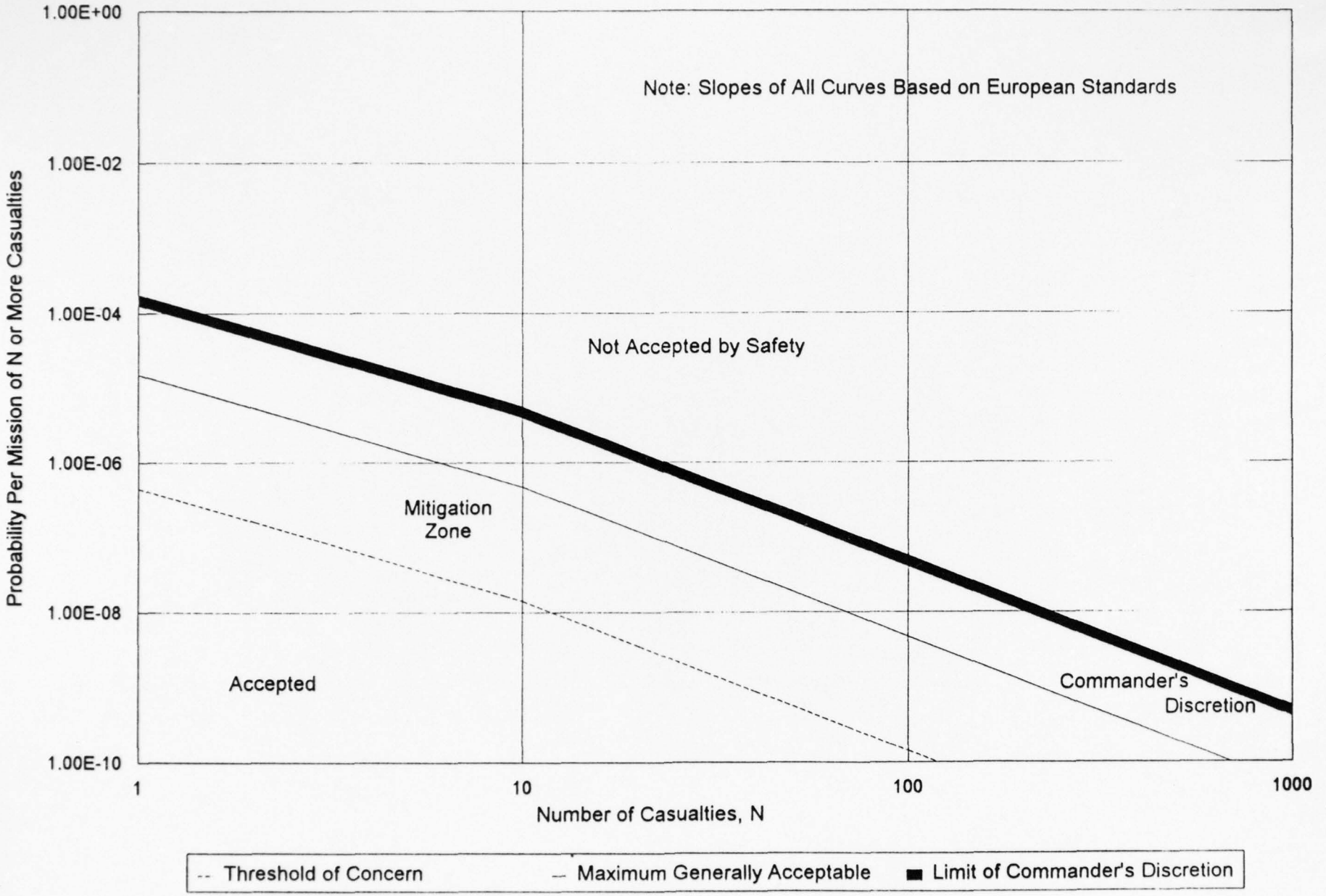
APPROACH 4A: PARALLEL BANDS OF ACCEPTABILITY



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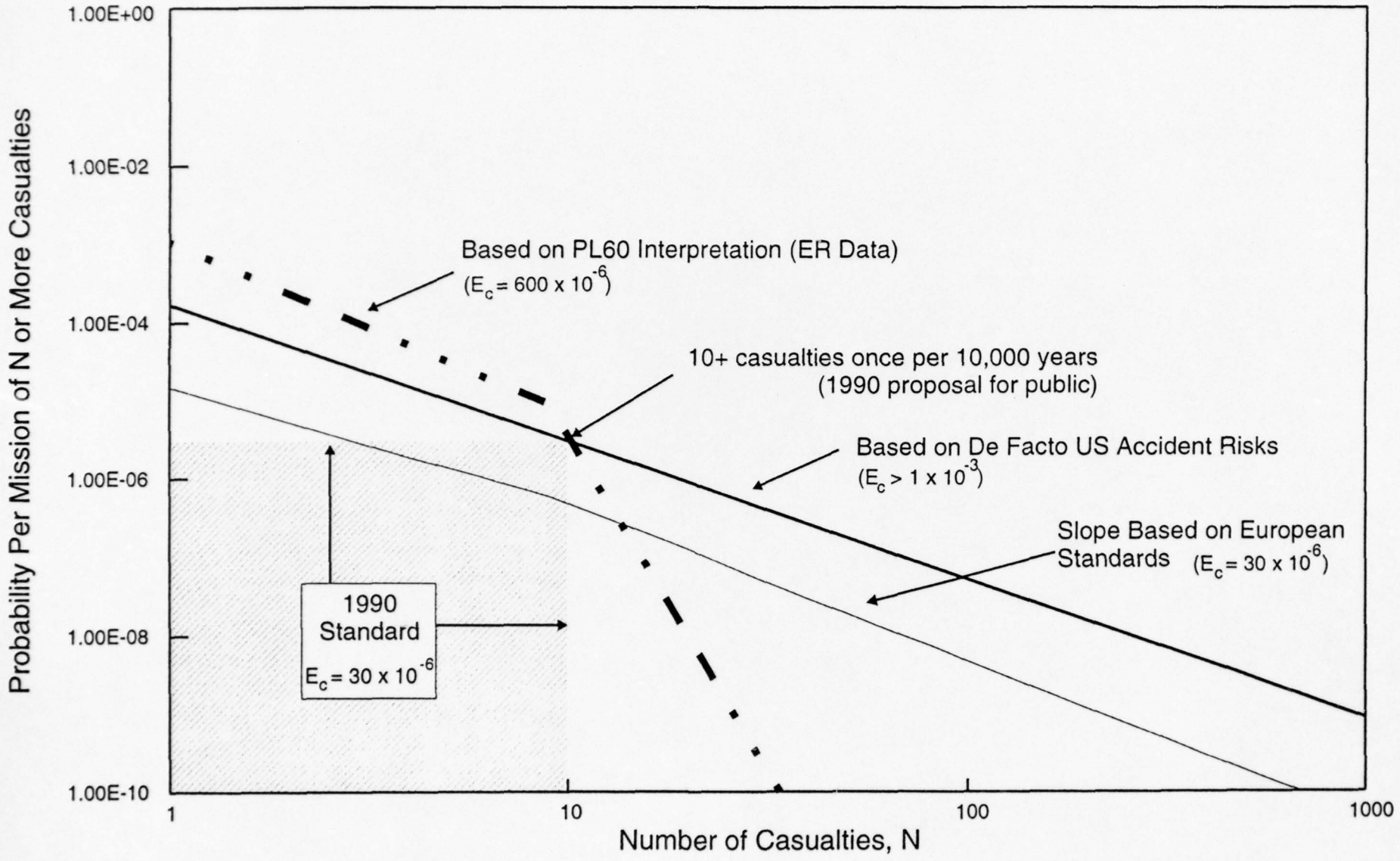
COMPARISON OF APPROACHES TO PUBLIC RISK PROFILE STANDARDS



ACCEPTABLE RISK WORKSHOP AGENDA

RECAP AND REVIEW OF PAST AGREEMENTS

TREATMENT OF MULTIPLE HAZARDS AND MULTIPLE LEVELS OF INJURY

RISK PROFILE STANDARDS

REAL TIME DECISION CRITERIA

HISTORY OF REAL-TIME DISPLAYS

VACUUM INSTANTANEOUS IMPACT POINT (IIP)

DRAG-CORRECTED IIP

DEBRIS PATTERN

STATISTICAL DEBRIS PATTERN

INSTANTANEOUS CASUALTY EXPECTATION

CONCEPT DESCRIPTION

PRELAUNCH DATA GENERATION → **REAL TIME COMPUTATION** → **DISPLAY FOOTPRINT AND E_c AND . . .**

CPLD
(Common Prelaunch Debris Program)

- Create database as a function of altitude, elevation angle, and speed.
- Uncertainties include:
  - explosion velocity
  - malfunction turn
  - Lift/Drag

(1) **CRTD**
(Common Real Time Debris Program)

- Compute drag corrected impact points in real time
- Compute wind dependent uncertainties:
  - Ballistic coefficient
  - wind time-delay
- Compute impact dispersion ellipses

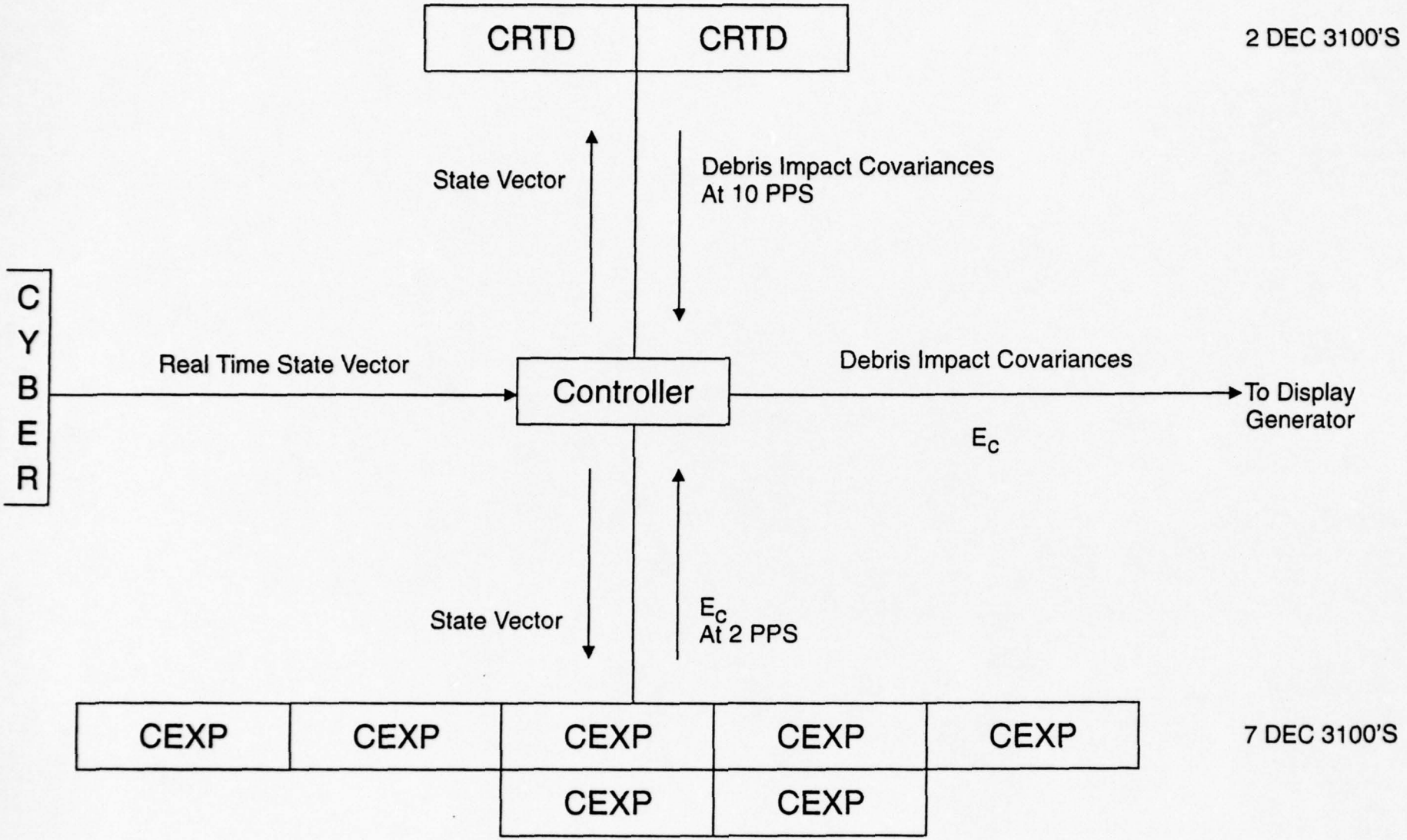
(2) **CEXP**
(Casualty Expectation)

- Compute conditional Ec

RSDDS
(Range Safety Debris Display System)

- Display impact dispersions (hazard)
- Display conditional E_c in some form (risk)
- Display destruct criteria

POSSIBLE REAL-TIME HARDWARE ENVIRONMENT



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DEMONSTRATION

OF

REAL TIME E_C

MOCK-UP

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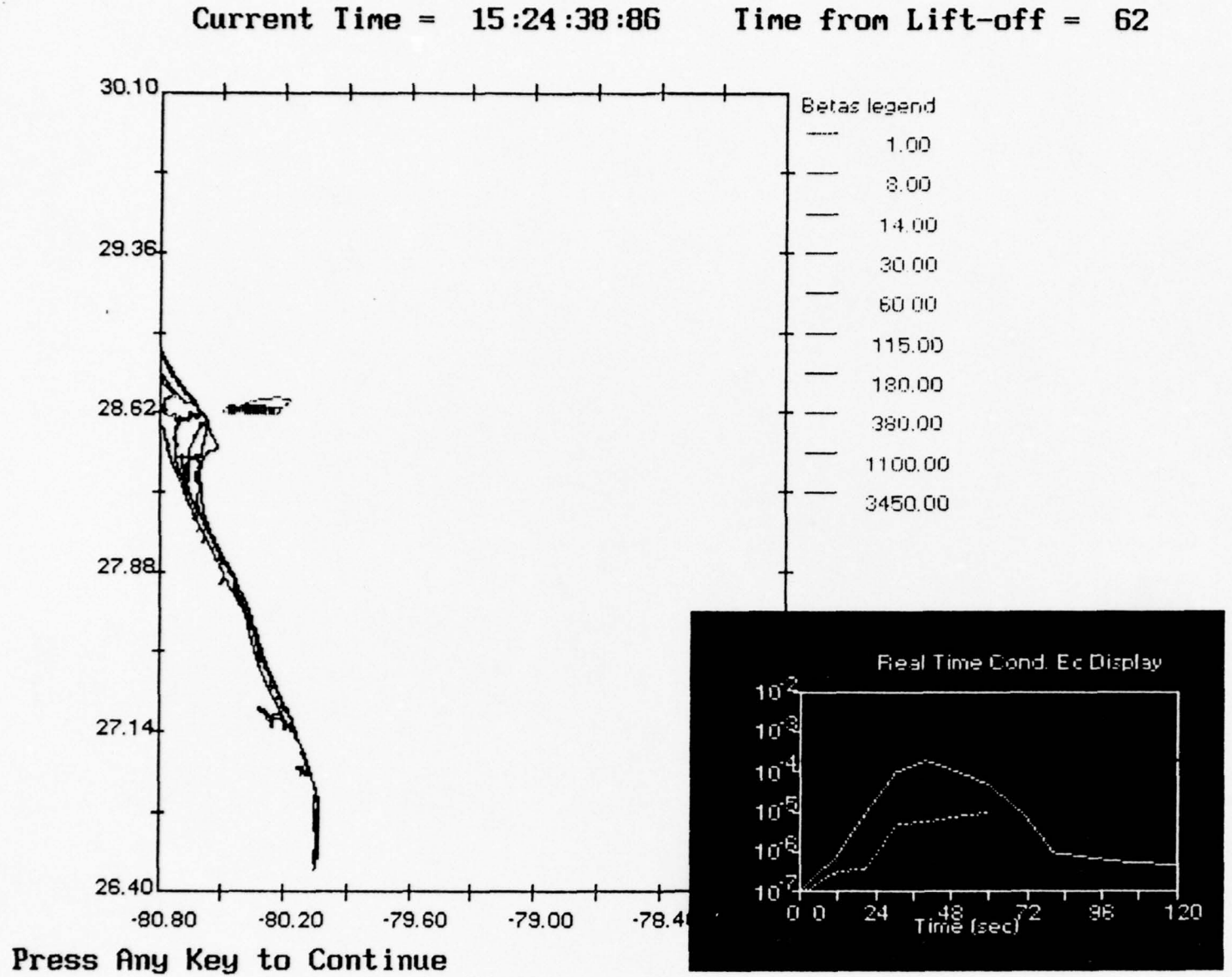
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30.10
29.36
28.62
27.88
27.14
26.40
-80.80
-80.20
-79.60
-79.00
Betas legend
1.00
8.00
14.00
30.00
60.00
115.00
180.00
380.00
1100.00
3450.00
Real Time Cond. Ec Display
Time (sec)
0 0
24
48
72
96
120
Press Any Key to Continue

[redacted]7/[redacted]RW[redacted]9

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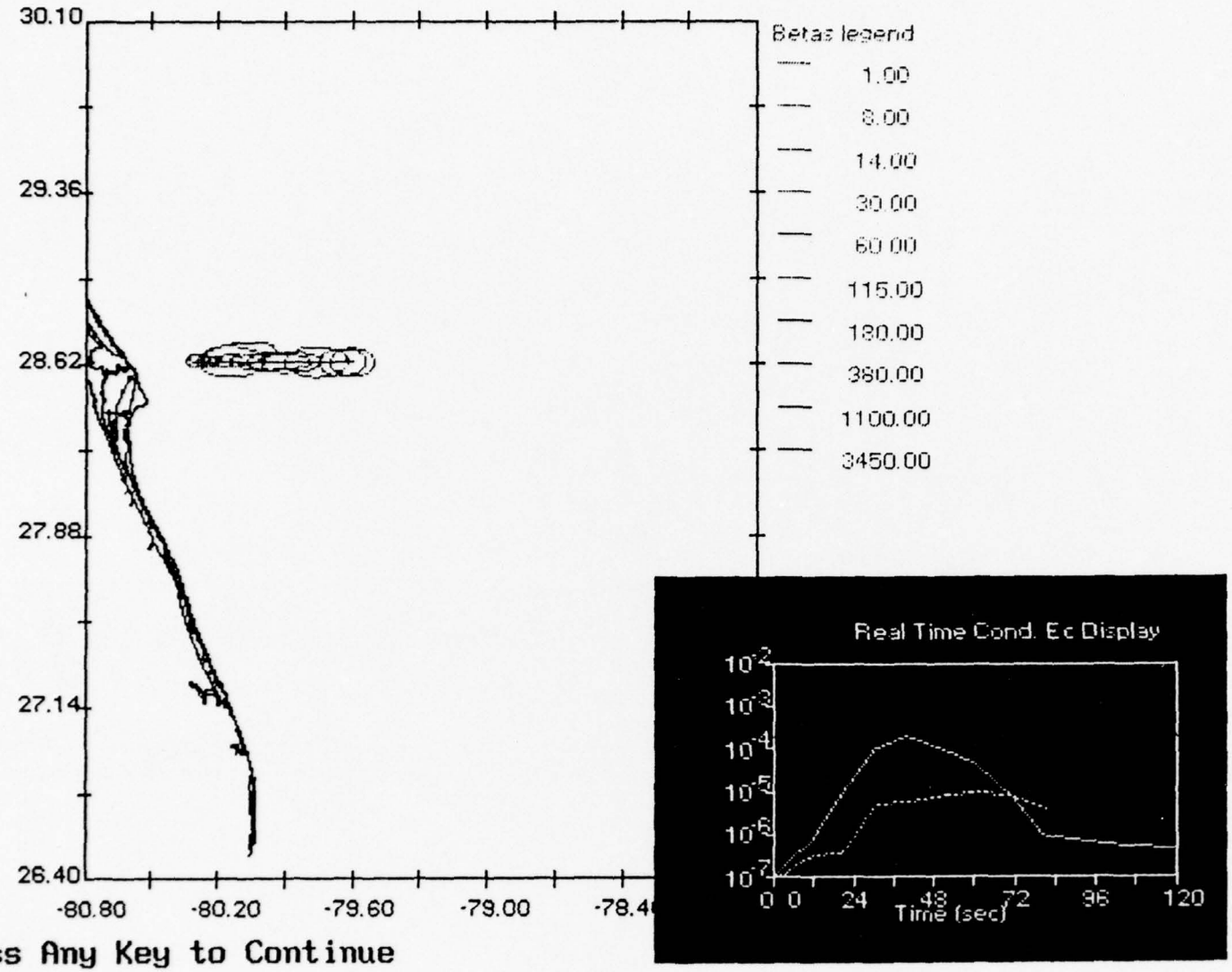

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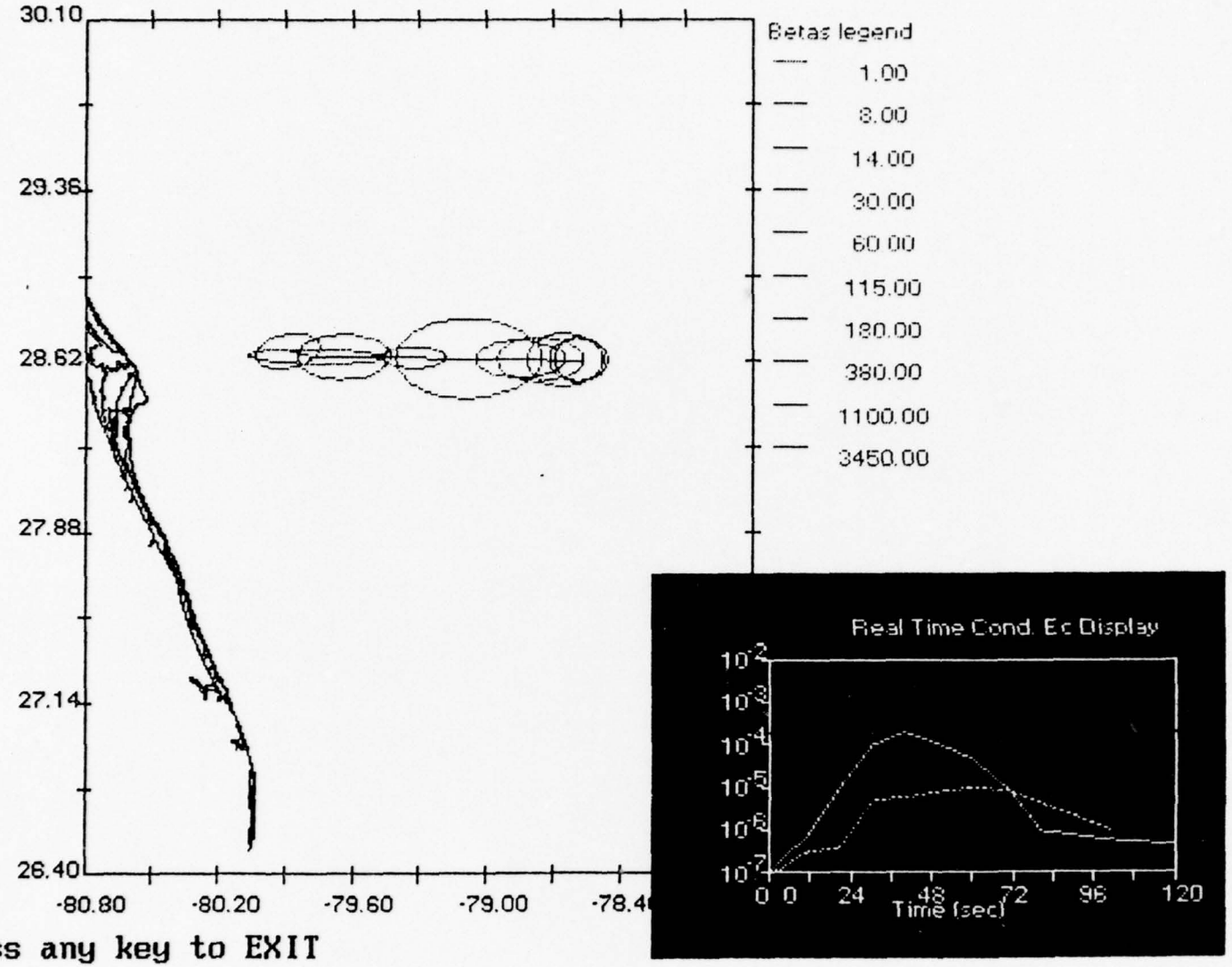

Press any key to EXIT

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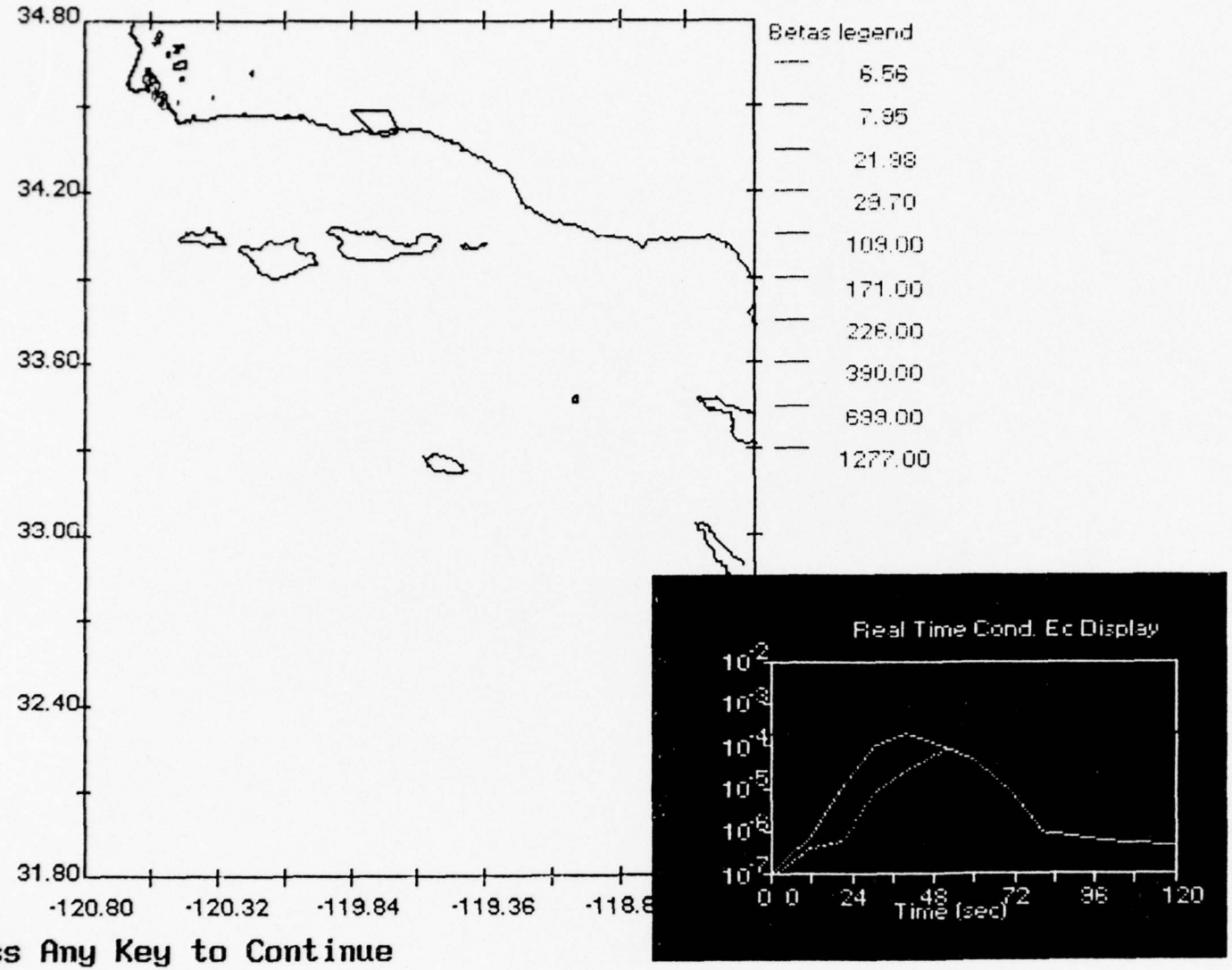

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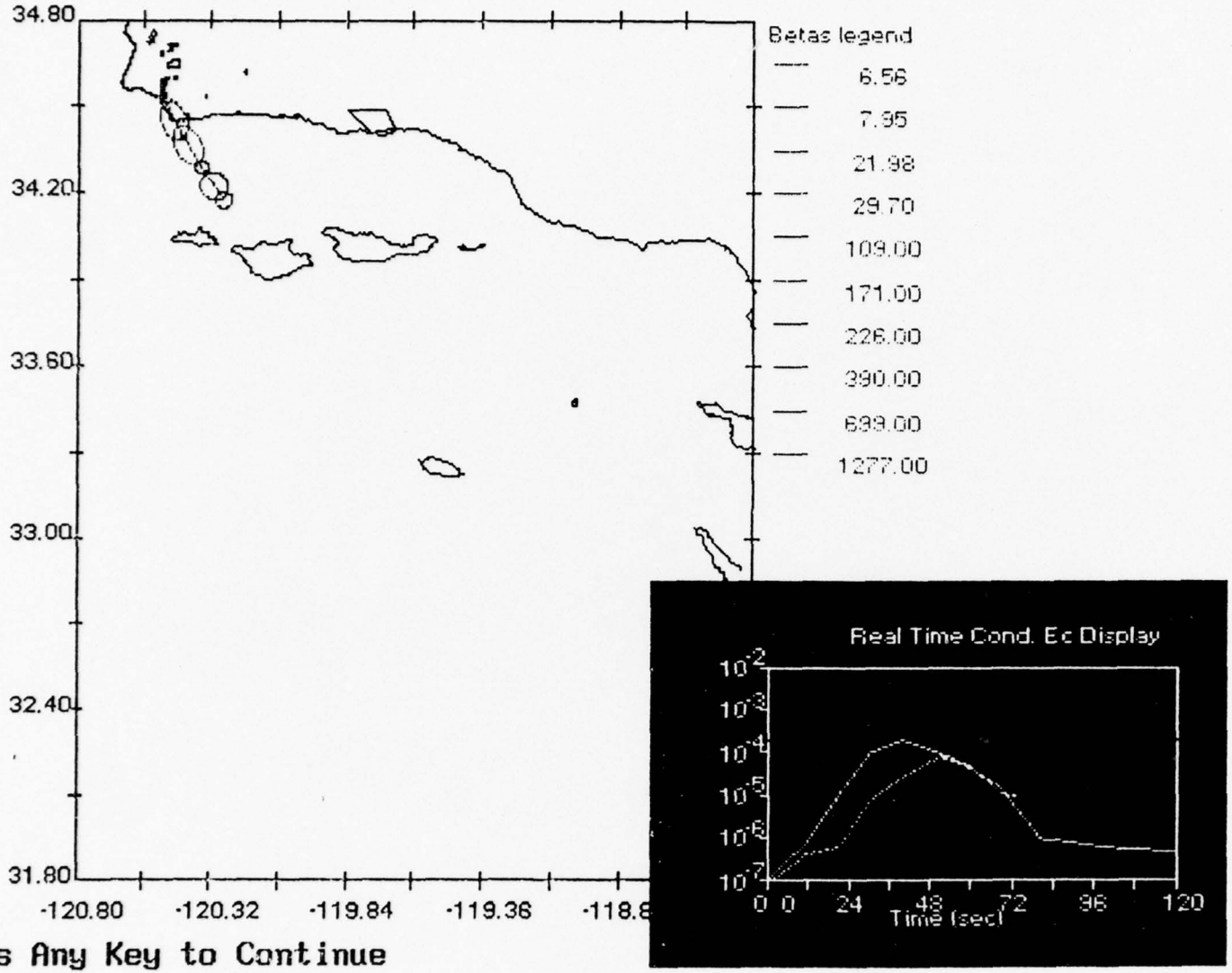

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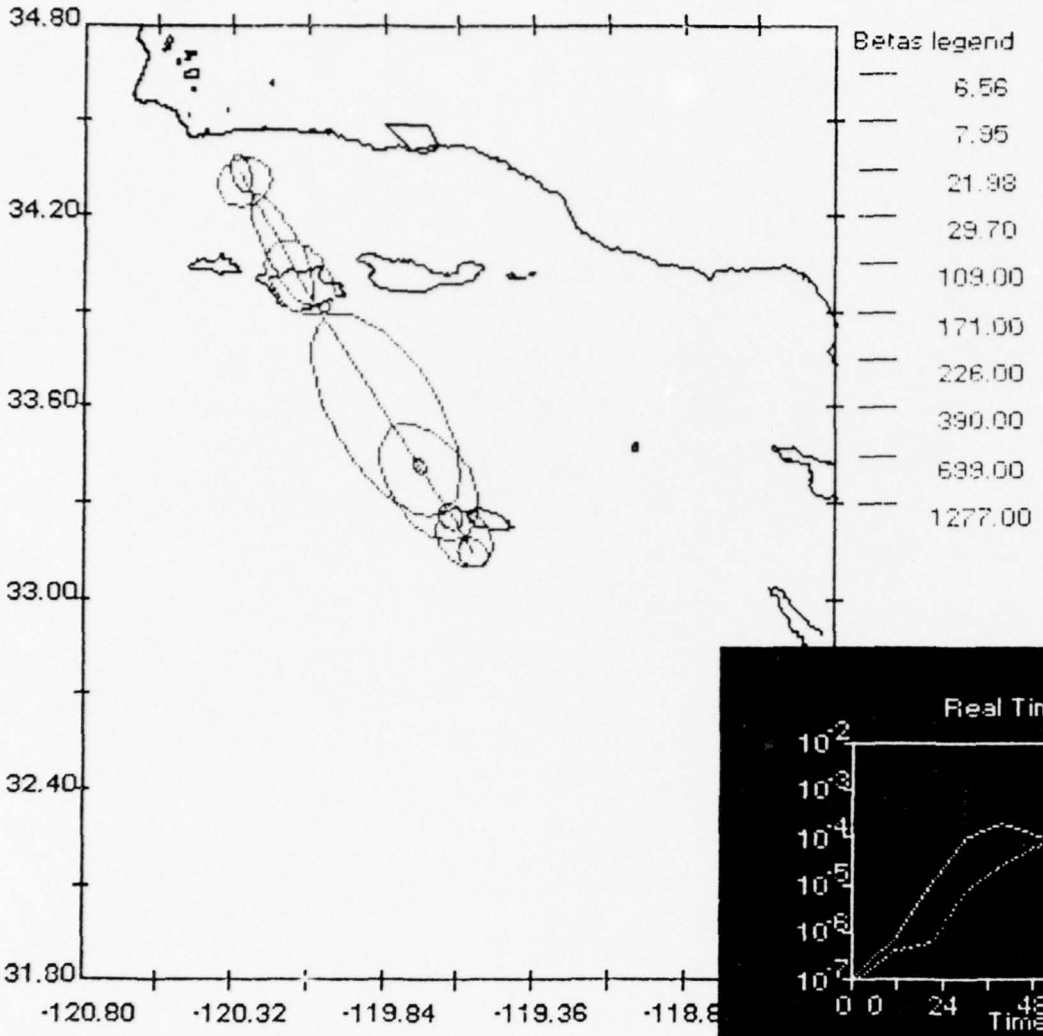
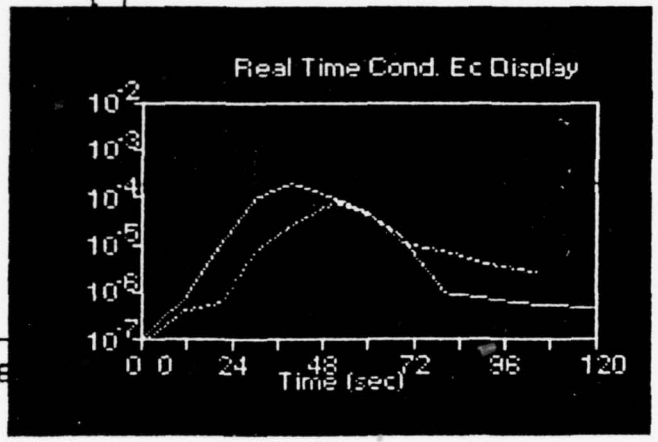




Press Any Key to Continue

APPENDIX

PL60

"RISK FROM AIRCRAFT OVERHEAD"

PL 60 UPDATE: CCAFS ANNUAL E_C (MILITARY AND GENERAL AVIATION)

ON-BASE POPULATION:

$$6 \times 10^{-5} \leq \text{ANNUAL } E_C \leq 2 \times 10^{-4}$$

OFF-BASE POPULATION:

$$2 \times 10^{-2} \leq \text{ANNUAL } E_C \leq 9 \times 10^{-2}$$

COMBINED POPULATION:

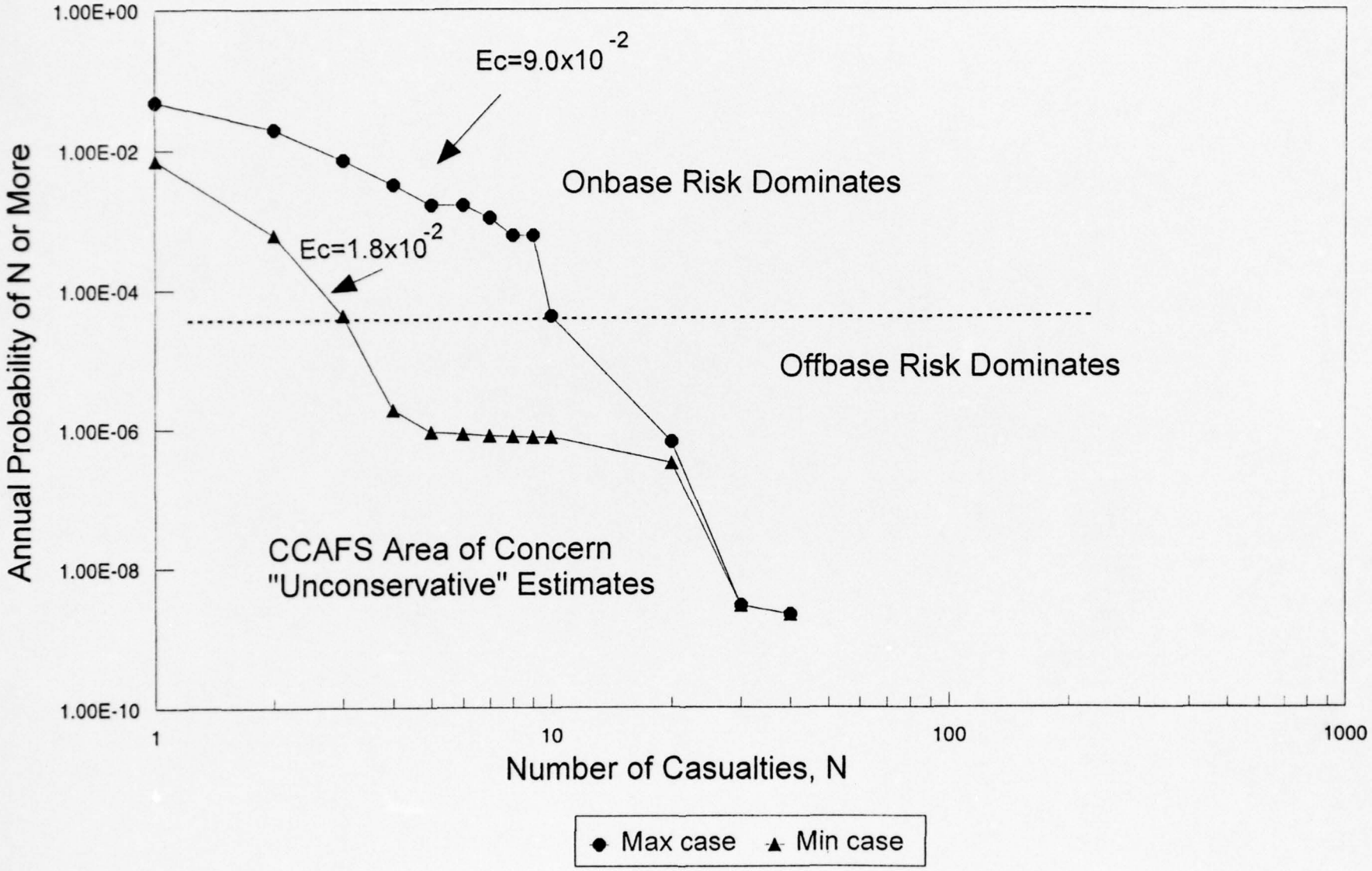
$$2 \times 10^{-2} \leq \text{ANNUAL } E_C \leq 9 \times 10^{-2}$$

LAUNCH RISK ACCEPTABILITY IMPLICATIONS

ADOPTED ACCEPTABLE RISK	POPULATION GROUP	"ACCEPTABLE" NUMBER OF LAUNCHES*
300×10^{-6}	ON-BASE	0 - 1
30×10^{-6}	OFF-BASE	670 - 3000
30×10^{-6}	TOTAL	670 - 3000

** ASSUMING AVERAGE E_C PER LAUNCH AT ALLOWABLE MAXIMUM*

RISK PROFILES FOR COMBINED MILITARY AND GENERAL AVIATION, (ON-BASE AND OFF-BASE POPULATION)



RELATIVE SIGNIFICANCE

OF

DIFFERENT INJURY LEVELS

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RELATIVE FREQUENCY OF INJURY LEVELS

INJURY LEVEL	ALL	WORK	HOME
DEATH	1.0	1.0	1.0
PERMANENT DISABILITY	3.6	5.8	4.0
TEMPORARY TOTAL DISABILITY	91	154	147

SOURCE: ACCIDENT FACTS 1990 EDITION

PROBABILITY DISTRIBUTIONS OF WORKER'S COMP CLAIM (DOLLARS) BY LOSS CATEGORY (1984 DATA)

LOSS CATEGORY	PROBABILITY	CLAIM ($)
DEATH	0.20	$ 7,287
	0.20	35,006
	0.20	73,434
	0.20	91,373
	0.20	95,931
OTHER (PERMANENT TOTAL, MAJOR PERMANENT, TEMPORARY DISABILITY)	0.60	$ 15,000
	0.30	35,000
	0.07	80,000
	0.02	125,000
	0.01	500,000
MEDICAL ONLY	0.2	$ 21
	0.2	64
	0.2	128
	0.2	129
	0.2	417

WORKER'S COMP CLAIM GUIDELINES

(CALIFORNIA 1991)

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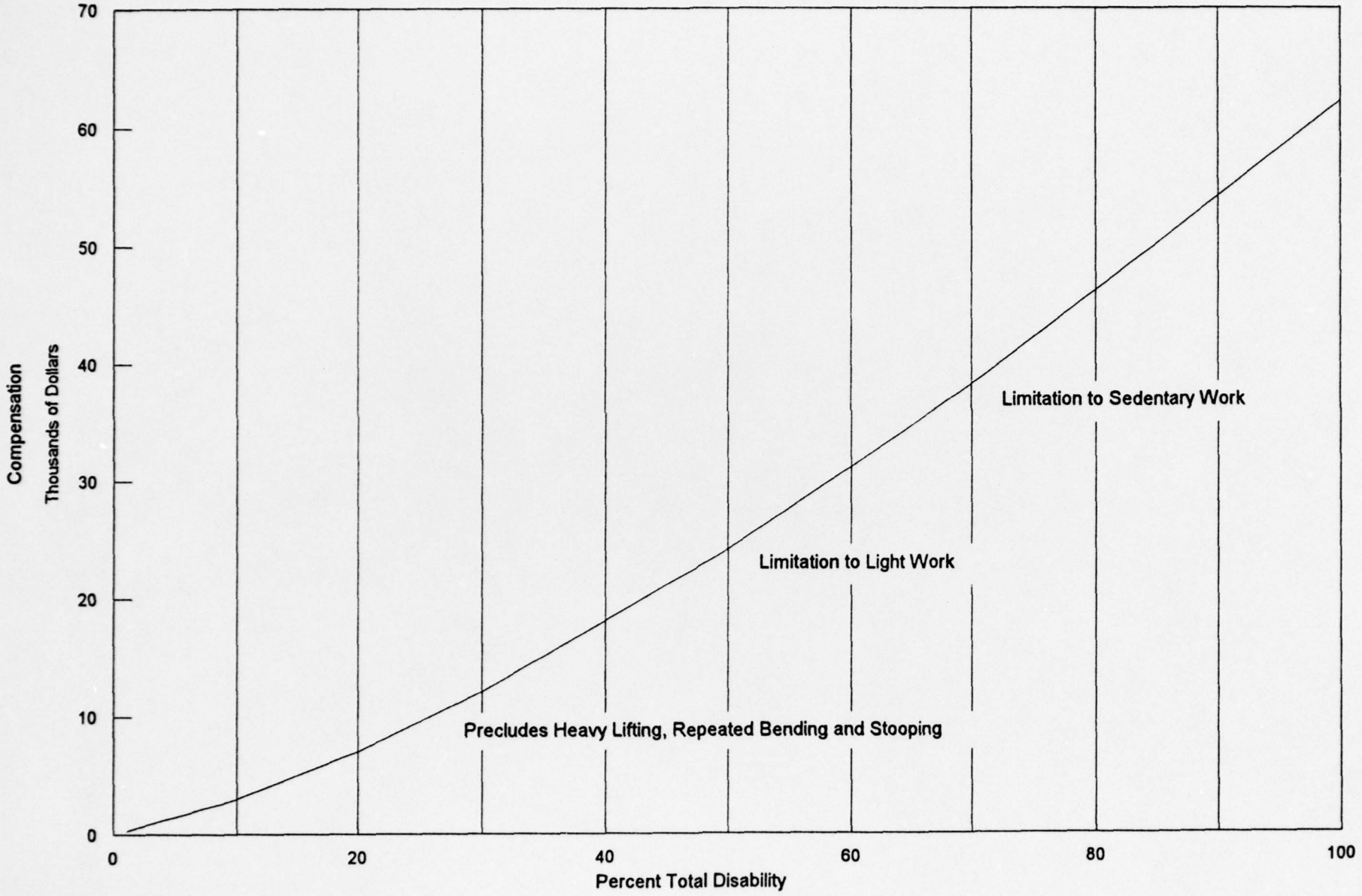
WORKER'S COMP CLAIM GUIDELINES
(CALIFORNIA 1991)



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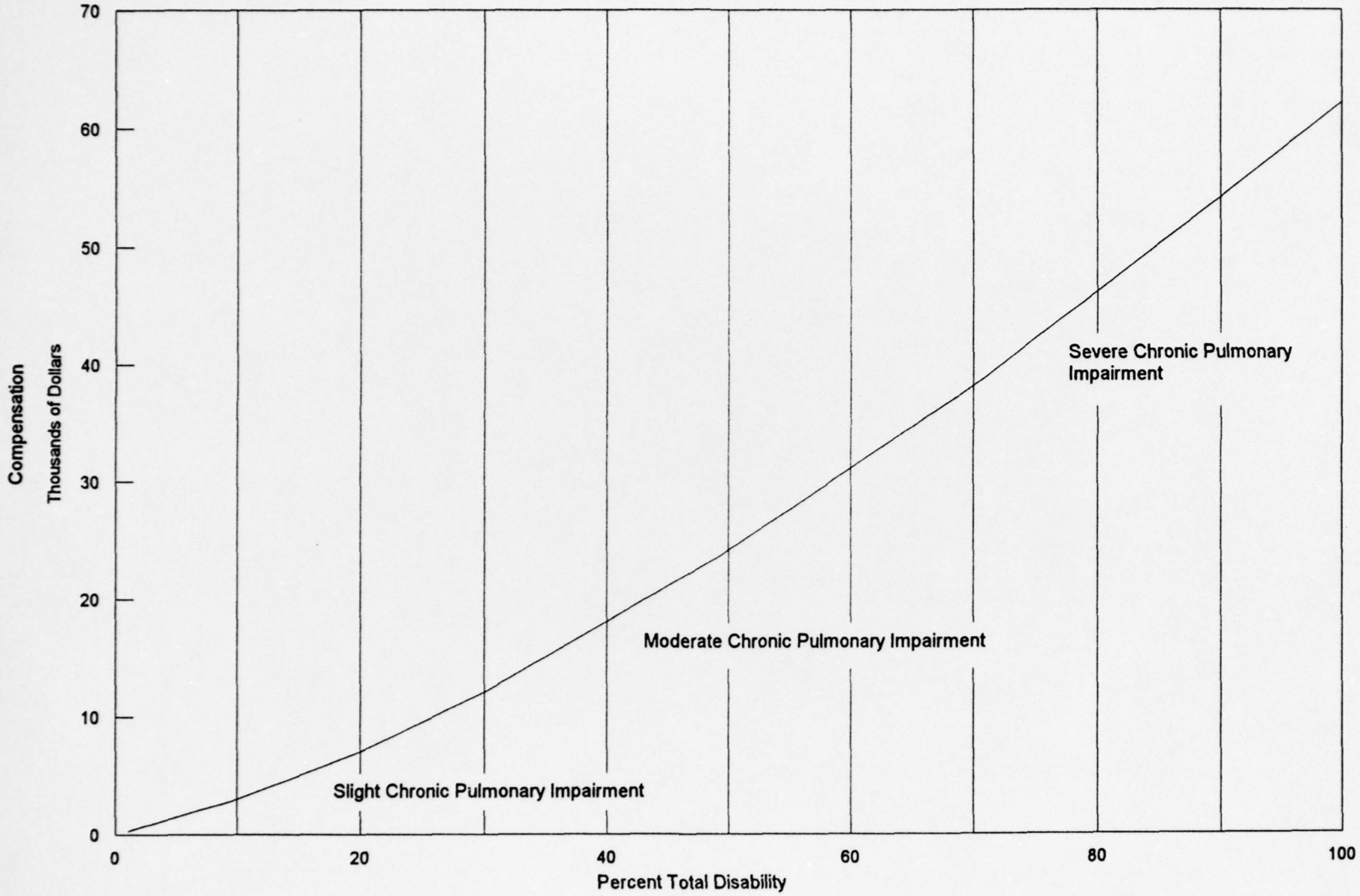
WORKER'S COMP CLAIM GUIDELINES
(CALIFORNIA 1991)



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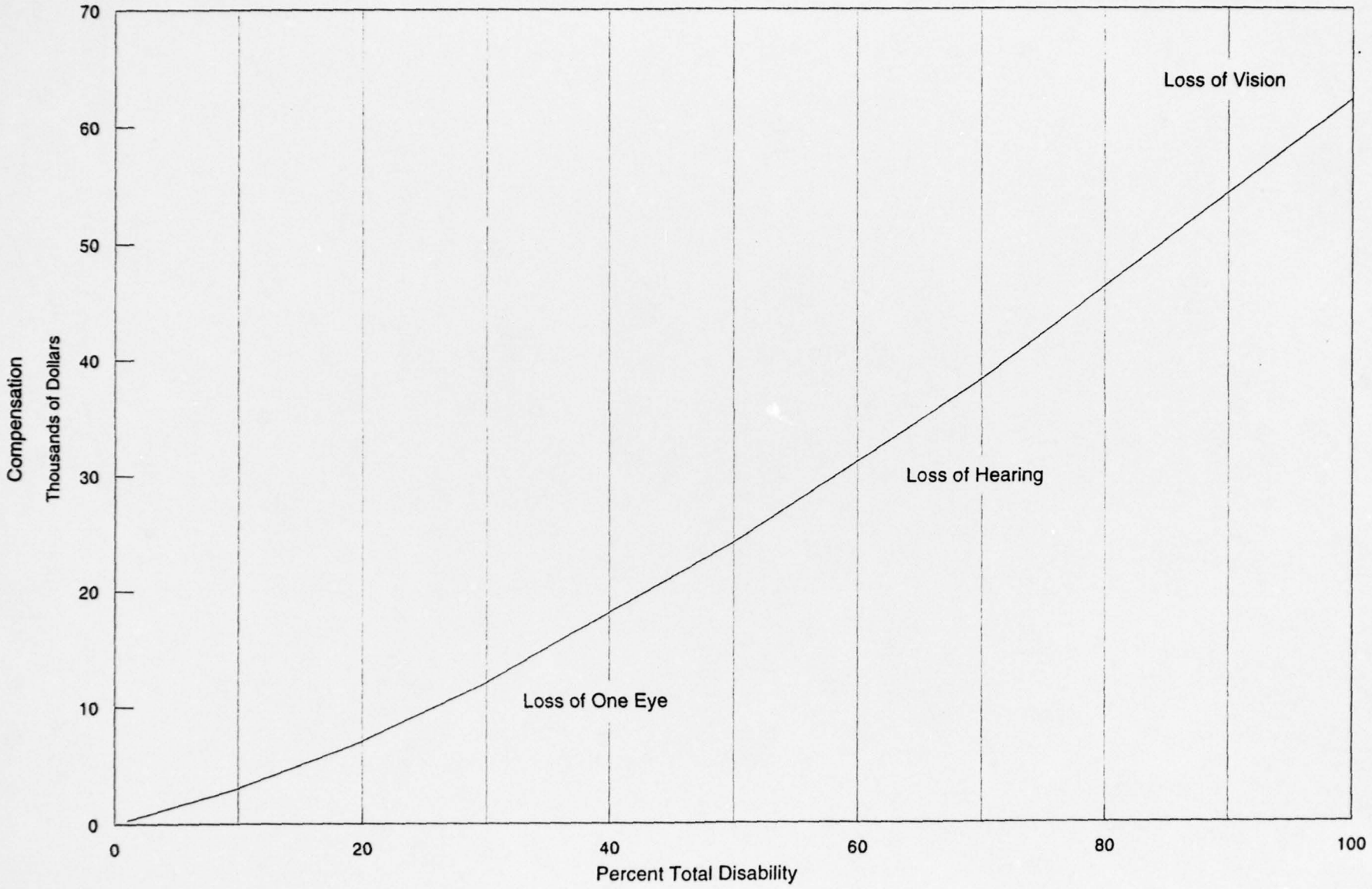
WORKER'S COMP CLAIM GUIDELINES
(CALIFORNIA 1991)



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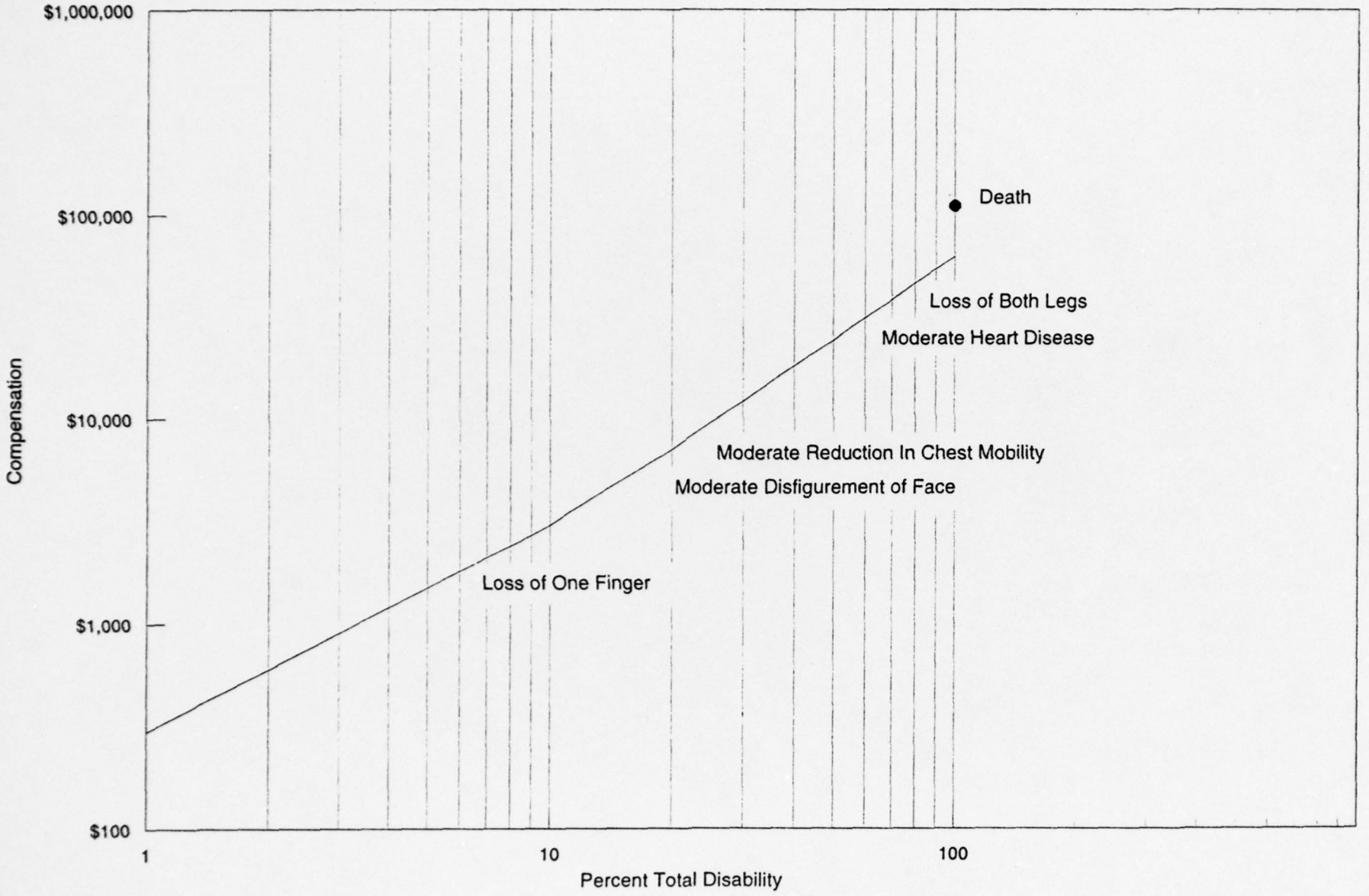
WORKER'S COMP CLAIM GUIDELINES
(CALIFORNIA 1991)



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TOTAL ECONOMIC VALUE

COST ITEMS	MEDICAL ONLY	TEMPORARY DISABILITY	MINOR PERMANENT DISABILITY	MAJOR PERMANENT DISABILITY	PERMANENT TOTAL DISABILITY	DEATH
AMBULANCE	$500	$500	$500	$500	$500	$500
EMERGENCY CARE	$1,000	$10,000	$10,000	$10,000	$10,000	$10,000
MEDIUM TERM CARE		$25,000	$25,000	$25,000	$25,000	
LONG TERM CARE			$25,000	$30,000	$30,000	
LOST WAGES		$10,000	$250,000	$650,000	$1,000,000	$1,000,000
LOST VALUE OF WORK		$20,000	$500,000	$1,300,000	$2,000,000	$2,000,000
EFFECT ON RANGE		$100,000	$500,000	$10,000,000	$100,000,000	$100,000,000
TOTAL	$1,500	$165,500	$1,310,500	$12,015,500	$103,065,500	$103,010,500
ORDER OF MAGNITUDE	$2.E3	$2.E5	$1.E6	$1.E7	$1.E8	$1.E8
RATIO OF COST TO DEATH COST	.00002	.002	.01	.1	1	1